EXPLORING PEOPLE’S PERCEPTIONS OF BIODIVERSITY AND ECOSYSTEM SERVICES IN TAITA HILLS, KENYA

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Abstract

Taita Hills are situated in southeastern Kenya (03°20'S 38°15'E), only 350 km from the equator. Ecology and biodiversity of the area is one of a kind and has been subject to multiple studies of natural sciences during the last decades. Taita Hills belong to the Eastern Arc Mountains, an ancient chain of mountains in Eastern Africa and one of the 25 biodiversity hotspots of the world. To qualify as a biodiversity hotspot an area must have lost significant amounts of its original vegetation and inhabit a number of endemic plant species. Both of these criteria are met in Taita Hills where the favorable climate enables endemic species to thrive. Large areas of forest has been cut down in order get more room for agriculture, the main source of livelihood in Kenyan countryside, making the environment threatened.

The diverse environment of Taita Hills produces a multitude of ecosystem services. Ecosystem services can be defined as all benefits people obtain from nature. They are often divided into four categories: provisioning services, regulating services, cultural services and supporting services. Ecosystem services link ecological knowledge and economics together by enabling monetary valuation of abstract aspects of nature (e. g. water retention). This link helps decision makers to take environmental issues into consideration by providing a possibility to compare concrete and abstract aspects of nature with each other through tangible monetary values. Research on ecosystem services has grown exponentially in the recent years and decades. However, most of this research has been conducted in developed countries and only little research has been completed in developing countries such as Kenya. It has been established that provisioning services are considered the most important services in developing countries, though. This was the case in Taita Hills, too; the majority of ecosystem services recognized by the local people were provisioning services. Services like firewood, medicinal usage of local plants and scenery were familiar to local people and the role of water was also emphasized in their perceptions of ecosystem services and biodiversity as a whole. *Phoenix reclinata* was one of the keystone species of ecosystem services.

People's perceptions of biodiversity can vary a lot. Like ecosystem services, biodiversity is a subjective concept that can be understood differently by different people. Understanding how people see nature that surrounds them and biodiversity it beholds can help e. g. in planning nature conservation areas. When people agree on decisions made about their environment and recognize their own basic values in the decisions made they are more eager to support them. Even so, research on people's perceptions of biodiversity is currently lacking. Results that have been obtained have suggested that plants' role in people's perceptions is emphasized and people respond better to beautiful and imposing species than modest or ugly species. This was true also in Taita Hills where people linked plants and forest directly to biodiversity. They also recognized local plant species well, regardless of their nativeness, and had a close relationship with nature overall.

Keywords
ecosystem services, biodiversity, introduced species, attitudes, perceptions

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Tiivistelmä

Taitavuoret sijaitsevat kaakkois-Keniassa (03°20'S 38°15'E) vain 350 kilometrin päässä päiväntasaajasta. Taitavuorten ainutlaatuista ekologiaa ja biodiversiteettiä on tarkasteltu monissa alueella tehdyissä tutkimuksissa viime vuosikymmenien aikana. Taitavuoret kuuluvat Itäisiin kaarivuoriin, jossa on yksi maailman 25 biodiversiteetin keskittymästä (biodiversity hot spot). Biodiversiteetin keskittymästä on kyse silloin, kun alueelta on hävinnyt suuria määriä alkuperäistä kasvillisuutta ja alueella elää monia endeemisiä kasvilajeja. Taitavuoret täyttävät molemmat kriteerit; suotuisat ilmasto-olot mahdollistavat endeemisten lajien olemassaolon ja suuria alueita metsää on hakattu maanviljelyksen tieltä. Maanviljelys on Kenian maaseudun tärkein elinkeino.

Taitavuorten monimuotoinen ympäristö tuottaa paljon erilaisia ekosysteemipalveluita. Ekosysteemipalvelut määritellään yleisesti ihmisen luonnosta saamiksi hyödyiksi ja ne jaetaan usein neljään kategoriaan: tuotantopalveluihin, säätelypalveluihin, kulttuuripalveluihin ja ylläpitopalveluihin. Ekosysteemipalveluiden avulla voidaan yhdistää ekologinen tieto taloudellisiin arvoihin, jolloin voidaan antaa rahallisia arvoja myös luonnon abstrakteille ominaisuuksille (esimerkiksi maaperän vedenpidätyskyvylle). Tämä voi auttaa päätöksentekijöitä ottamaan ympäristöasiat huomioon päätöksentekotilanteissa. Ekosysteemipalveluiden tutkimus on kasvanut eksponentiaalisesti viime vuosien ja vuosikymmenien aikana. Suurin osa tästä tutkimuksesta on kuitenkin tehty kehittyneissä länsimaissa kun taas Kenian kaltaisissa kehittyvissä maissa tutkimusta on tehty vähemmän. Tuotantopalveluja pidetään kuitenkin tärkeimpänä ekosysteemipalveluiden kategoriana nimenomaan kehitysmaissa. Tämä piirre oli huomattavissa myös Taitavuorilla, jossa suurin osa paikallisten ihmisten tunnistamista ekosysteemipalveluista oli tuotantopalveluita. Ekosysteemipalvelut kuten polttopuukäyttö, paikallisten kasvien lääkekäyttö ja maisema olivat tuttuja paikallisille asukkaille ja veden rooli kaikissa ihmisten luontokäsityksessä oli tärkeä. *Phoenix reclinata* oli yksi ekosysteemipalveluiden avainlajeista.

Ihmisten käsitykset biodiversiteetistä vaihtelivat paljon. Kuten ekosysteemipalvelut, myös biodiversiteetti on hyvin subjektiivinen käsite, jonka eri ihmiset ymmärtävät eri tavoin. Esimerkiksi luonnonsuojelualueita suunniteltaessa on kuitenkin tärkeää ymmärtää ihmisten käsityksiä liittyen ekosysteemipalveluihin ja biodiversiteettiin; kun ihmiset pitävät tehtyjä päätöksiä hyvinä ja omien arvojensa mukaisina, he myös kannattavat niitä innokkaammin. Tästä huolimatta tutkimusta ihmisten ekosysteemipalvelu- ja biodiversiteettikäsityksistä on olemassa vain vähän. Saadut tulokset viittaavat siihen, että kasvien rooli ihmisten käsityksissä on korostunut ja että ihmiset arvostavat enemmän esteettisesti kauniita ja näyttäviä lajeja kuin rumia ja mitäänsanomattomia lajeja. Samaan tulokseen päädyttiin myös tässä tutkimuksessa Taitavuorilla, sillä paikalliset ihmiset liittivät kasvit ja metsäympäristön suoraan alueen biodiversiteettiin. He myös tunnistivat paikalliset kasvilajit hyvin riippumatta lajien alkuperästä ja heidän suhteensa luontoon ylipäänsä oli läheinen.

Avainsanat
ekosysteemipalvelut, biodiversiteetti, tulokaslajit, asenteet, käsitykset

Säilytyspaikka
ympäristötieteiden laitoksen kirjasto, Lahti

Muita tietoja

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1. Introduction

Fruits, firewood and water are things that many people recognize as benefits obtained from nature. But what about soil formation, beautiful sceneries or pollination? Can regular people recognize and name them as benefits produced by the environment? This is part of what this thesis sets out to discover. All six benefits mentioned above are ecosystem services. They represent all four ecosystem service categories that are provisioning services (fruits, firewood, water), regulating services (pollination), cultural services (scenery) and supporting services (soil formation). The simplest way to define ecosystem services is to say they are benefits people obtain from nature (MA 2005c). In this thesis different definitions of ecosystem services will be further explored and ecosystem services from the environment of Taita Hills will be identified.

Biodiversity and ecosystem services are linked to each other in many ways. The basic idea is that biodiversity increases the count of ecosystem services and vice versa (Schneiders et al. 2012). There are some exceptions for this, however, and the situation gets even more complicated when biodiversity is considered an ecosystem service on its own. The role of biodiversity in providing or inhibiting ecosystem services will also be studied in this thesis.

Ecosystem services and biodiversity are both concepts that are used a lot in the scientific world and decision-making processes. Majority of people know the terms and have some idea what they mean but the actual knowledge of what regular people think of ecosystem services and biodiversity is currently lacking (Fischer et al. 2011). One purpose of this thesis is to find out regular people's perceptions of ecosystem services and biodiversity in Taita Hills. These perceptions can then be compared to the general scientific ideas and the potential differences can be discovered. One aspect is to compare the opinions of respondents inside Taita Hills, too. Hopefully this will provide new information for both scientific world and local people. Results could be used e. g. in the planning of nature conservation areas in Taita Hills region.

The original assumption for the results of this thesis is that local people recognize mostly provisioning services (e. g. food, firewood) in the study species and do not have equally clear understanding about other ecosystem service categories, such as regulating services (e. g. water retention, carbon sequestration). This assumption is based on the research by Egoh et al. (2012) that states that provisioning services are the most recognized ecosystem services in developing countries. Another viewpoint of this thesis is to find out if local people make any difference between indigenous and exotic species. It has been studied that when it comes to the desirability of a species, its nativeness plays only a small role (Fischer et al. 2011) so the assumption here is that local people do not differentiate indigenous and exotic species that much. One of the goals of this study is also to investigate how local people understand the concept of biodiversity. This abstract concept means different things to different people (Fisher et al. 2009) and can in fact mean different things in different contexts. Regular people's perceptions of biodiversity are currently quite poorly known and understood (Fischer et al. 2011) so this study also tries to unveil the attitudes of Kenyan people towards their environment and add to the current knowledge of the subject.

2. Taita Research Station in Taita Hills

Taita Hills are situated in southeastern Kenya, Africa. They belong to The Eastern Arc Mountains, an ancient mountain range in Tanzania and Kenya. Ecology and biodiversity of Taita Hills are very distinctive and the area has therefore been an object of growing scientific interest during the last decades. Partly as a result of this growing interest in the area Taita Research Station was founded there.

Taita Research Station, owned by the University of Helsinki, was the base of research in this study. The research station has been founded in Taita Hills in 2011 and functions now among other things as an accommodation facility for various researchers coming to Taita Hills to start, continue or complete their research. The research station is situated in central location in Wundanyi, the capital of Taita Hills.

Multiple research projects concerning Taita Hills are underway at the moment and Taita Research Station has provided a suitable location for different stakeholders to gather and communicate about them. TAITAWATER and CHIESA are few of the biggest ongoing research projects at the moment in Taita Hills. This thesis is part of TAITAWATER project that researches different aspects of water usage in the area. It also studies the unique hydrology of Taita Hills.

Taita Research Station has provided an opportunity for many MSc and PhD students to carry out their research in an environment suitable for different kinds of biological, ecological or geographical studies. In the years 2011-2013 around ten MSc theses and five doctoral dissertations have been completed in Taita Research Station. The first MSc theses concerning Taita Hills were completed already in 1990s, however, before the place was formally called Taita Research Station.

2.1 The diverse environment of Taita Hills

Taita Hills are situated in southeastern Kenya, rising from the dry Serengeti plains and covering an area of about 1000 km^2 (Maeda et al. 2010). The highest point of Taita Hills reaches over 2200 m from sea level and the altitudinal range of forest is 1500-2140 m (Burgess et al. 2007). The highest hilltops are an object of constant mist and cloud precipitation making the vegetation there flourish. Taita Hills are situated in the Intertropical Convergence Zone which means there are two rain seasons; the longer one occurs from March to May and the shorter one from November to December. (Pellikka et al. 2009) Outside of these rain seasons the vegetation in Taita Hills is much scarcer, especially in the lower zones where the heat withers plants quickly without water.

Ecology

A phenomenon called orographic rainfall makes the southeastern slopes of Taita Hills receive more precipitation than the northwestern slopes (Pellikka et al. 2009). The phenomenon is portrayed in Fig. 1. When warm and moist air from the sea meets geographic barrier, the barrier forces the air to go upward. When the air rises, it cools and releases its moisture in the form of precipitation. As the air continues its journey to the other side of the barrier it warms again and becomes drier, creating a so called rain shadow on the lee slope (the slope not facing the wind). As a result, the windward slope (the slope facing the wind) gets much more precipitation than the lee slope which also affects vegetation on both slopes. In the case of Taita Hills, the wind from The Indian Ocean creates a rain shadow to the northwestern slopes of Taita Hills making them drier and scarcer in vegetation. Because of this the southeastern slopes are more prone to farming as they receive more precipitation due to the orographic rains. Both windward and lee slopes are efficiently cultivated in Taita Hills, however. This small-scale farming (Fig. 2) typically produces maize, beans, tomatoes, peas, cassava, cabbages, banana and potatoes.

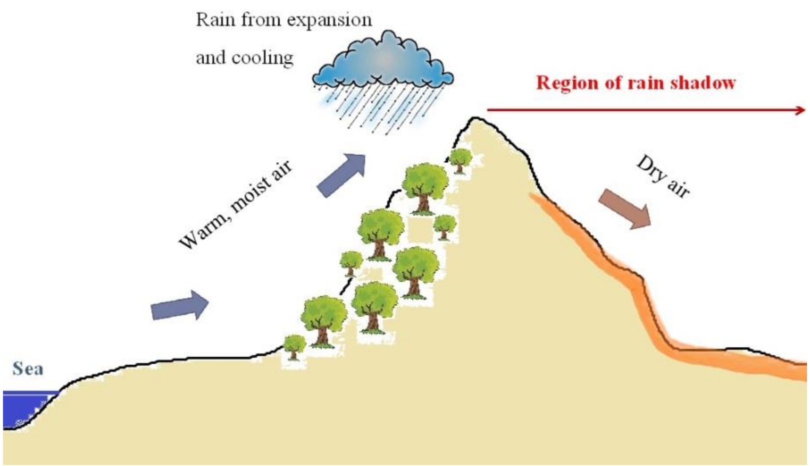

Figure 1. Orographic rainfall makes opposite slopes of the same hill differ in vegetation. Picture by E. Tuomaala (2013).

Agricultural production is the main source of economical income in many African countries. Vast areas have been converted to farmland in order to answer the needs of agriculture at the expense of natural vegetation in these countries (Egoh et al. 2012) and Taita Hills, Kenya is no exception; forests have been cut down in order to get more land for farming. Economic growth in many tropical countries typically happens this way, at the expense of natural ecosystems, when forested area is converted to something else (Schroth & McNeely 2011).

Figure 2. Small-scale farming in terraced slopes in Taita Hills. Photograph by E. Tuomaala (2013).

Agriculture is a fundamental source of livelihood in Taita Hills (Himberg 2011). Climatic and soil conditions are very suitable for farming in Taita Hills which has resulted in clearing forest in order to get more farmland in some areas (Pellikka et al. 2009). This has affected the ecology of Taita Hills as forest ecosystems have artificially been converted to farm ecosystems through human impact. In The Eastern Arc Mountains, Taita Hills have been affected the most by agricultural expansion (Maeda et al. 2010). Construction of railways between 1898 and 1924 also affected forest cover of Taita Hills negatively when trees were cut down from the railway routes (Pellikka et al. 2009).

The loss of indigenous forest cover was fast between 1955 and 2004; in a study by Pellikka et al. (2009) annual reductions in forest cover were approximately 5 ha in the studied forest fragments which covered the overall area of around 520 ha. It is estimated that only 1% of the original forested area in Taita Hills remains there to this day (Maeda et al. 2010).

Biodiversity

Taita Hills are part of The Eastern Arc Mountains, one of the world's twenty-five biodiversity hotspots (Myers et al. 2000). The definition of a biodiversity hotspot by Myers et al. (2000) is that "a hotspot contains endemic plant species comprising at least 0.5% of all plant species world-wide" and has already lost 70% or more of its primary vegetation making it a very threatened environment. Twenty-five areas in the world meet these criteria and are considered as biodiversity hotspots (Fig. 3). These 25 hotspots comprise only 1.4% of Earth's land surface but they provide habitat for 44% of all vascular plant species and 35% of all species in four vertebrate groups (mammals, birds, reptiles and amphibians) (Myers et al. 2000). The Eastern Arc Mountains accommodate at least ninety-six endemic vertebrate species (Maeda et al. 2010).

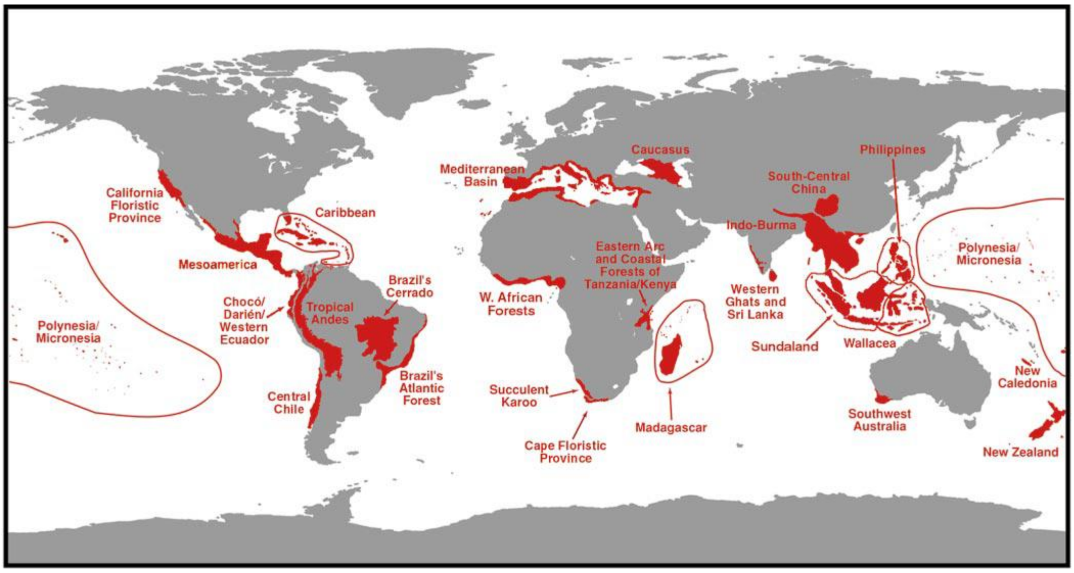

Figure 3. The twenty-five biodiversity hotspots of the world. (Myers et al. 2000)

Taita Hills belong to one of these hotspots defined by Myers et al. (2000) and therefore represent a diverse environment especially in terms of flora. Taita Hills are home to many endemic plant and animal species, for example *Impatiens teitensis* (Fig. 15), one of the study species in this thesis. Different vegetation zones can be found in Taita Hills because of the big elevation gradients found there. On mountaintops vegetation can be pine forest, on mountainsides vegetation varies from shrubbery to date trees and below the mountains vegetation can be almost savanna. The amount of water available for plants greatly dictates what kind of vegetation can be found where. The mountaintops are humid places and act much like water towers in Taita Hills area (Pellikka et al. 2013). Different vegetation zones support diverse flora and fauna in The Eastern Arc Mountains which is one of the reasons why they are listed as one of the world's twenty-five biodiversity hotspots.

The area of Taita Hills has both lost and gained forest cover during the last twelve years. This can be seen from a recent aerial image map made by Hansen et al. (2013) in Fig. 4. According to the map forest cover gain has been dominant in Taita Hills area overall but forest cover loss has concentrated in certain areas where the forest cover has been reduced quite significantly. The map does not tell anything about the tree species in question, however. Other studies (Pellikka et al. 2009) have shown that Taita Hills have specifically lost lot of its original tree cover meaning that the forest cover gain might be more or less the result of fast-growing introduced tree species. In a study by Pellikka et al. (2009) that explored the forest cover change in Taita Hills between the years 1955 and 2004 it was stated that the overall forest cover had remained almost the same during the studied 50 years but the composition of forest had drastically changed – half of the indigenous forest had been lost in that time and been replaced by exotic tree species. This change has probably had an effect on the biodiversity of Taita Hills, too.

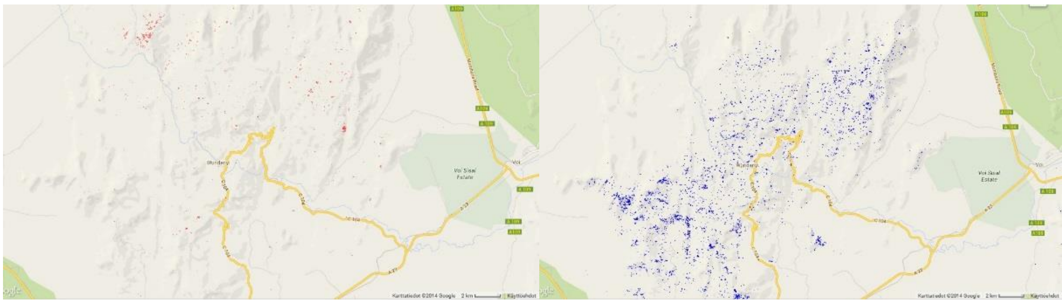

Figure 4. Forest cover loss can be seen as red (left) and forest cover gain in blue (right) in the Taita Hills area. (Hansen et al. 2013)

Indigenous forest areas provide many forest-restricted animal and plant species better living conditions than exotic plantations, so the increase of exotic forest cover in Taita Hills can result in degradation of animal and plant populations of the area. These changes in forest cover have also been expected to affect biodiversity and ecosystem services adversely. (Pellikka et al. 2009) This is not an uncontested viewpoint, however, because it is studied that many of the exotic trees introduced to new areas such as Taita Hills provide a variety of ecosystem services both old and new to the area (Young 2010). Exotic species can also increase biodiversity of the area if they succeed to grow side by side with old, indigenous species without suffocating their growth or overwhelming them, as they can provide new habitats and differing nutrition to the other species living there.

The forest areas of Taita Hills have been strongly altered by human actions over the past decades (Pellikka et al. 2009). The remaining forest is patchy and it is becoming even more fragmented and degraded (Bytebier 2001) as local people clear out forest in order to get more farmland. Fragmentation of environment can lead to a diminished biodiversity because it cuts off gene flow between the fragments. Its effects on bird populations have been studied also in Kenya and the results show that fragmentation often increases nest predation and therefore diminishes population sizes (Maina & Jackson 2003). This can eventually lead to biodiversity loss.

2.1.1 Taita Hills are home to both indigenous and introduced plant species

There are both indigenous and exotic plant species in Taita Hills. Taita Hills are also home for many endemic species from all domains. There are at least ninety-six endemic vertebrate species in Taita Hills (Burgess et al. 2007) and one of the study species in this thesis is an endemic plant species, too (*Impatiens teitensis*, Fig. 15). Some of the exotic species, especially plant species, have proven to be problematic to the environment by invading natural habitats of indigenous species and limiting their growth (Himberg 2011). Exotic plant species introduced to the area (e. g. *Eucalyptus sp.*) are often efficient in capitalizing available resources which can give them competitive advantage in re-colonization after wildfires or other damage to ecosystems. Some of the exotic species also have high demand for water which can lead to depletion of water resources and withering of indigenous plant species. Amongst the study species of this thesis there are seven indigenous plant species (*Albizia gummifera*, *Ficus sur*, *Impatiens teitensis*, *Orthostichella sp.*, *Phoenix reclinata*, *Pteridium aquilinum*, *Ricinus communis*), three exotic plant species (*Acacia mearnsii*, *Eucalyptus sp.*, *Tithonia diversifolia*) and one lichen (*Usnea sp.*). These species will be further introduced in chapter 5.2.

There are many exotic tree species that have settled completely in Taita Hills. Some were introduced there between 1950s and 1970s mostly for wood production, including cypress (*Cupressus lusitanica*), eucalyptus (*Eucalyptus sp.*) and different pine species (*Pinus elliottii, P. caribea and P. patula*). *Maesopsis eminii* and grevillea (*Grevillea robusta*) in turn were not introduced to Taita Hills until 1970s and 1980s. (Pellikka et al. 2009) These introduced species can have adverse effects to the environment. After the introduction of *Eucalyptus sp.* to Taita Hills it has spread quickly to the whole area. Eucalyptus is a very water-demanding tree species which has led to large Eucalyptus forests draining rivers and suffocating other indigenous plants in Taita Hills. One of the biggest biodiversity threats in Taita Hills evidently is the loss of indigenous forest and with that, the extinct of other indigenous species. In an effort to compensate for the lost indigenous forest local people and authorities have been trying to plant new introduced plant species to the area (Bytebier 2001). Unfortunately this has in some cases only made the original problem – the loss of indigenous plants – more severe as the competitive introduced species have overrun the indigenous species not used to such heavy competition.

Ngangao forest has lost a lot of its original plant species over the years. In 1955, the forest was nearly split in two parts – northern and southern Ngangao – due to the loss of forest in the middle. This loss of trees was mainly caused by agriculture practiced near the forest as well as forest fires. Government reacted to the degradation by establishing large pine and cypress plantations in Ngangao forest during the 1970s. (Pellikka et al. 2009) This stopped the forest from becoming two separate smaller forests, preventing harmful fragmentation of the environment, but at the same time new exotic tree species took up space from indigenous plant species in the forest. In 2004 different pine species and cypress covered 10.1 ha and 3.7 ha of the Ngangao forest, respectively. The total area of Ngangao forest in 2004 was about 200 ha divided almost equally to exotic and indigenous tree cover. (Pellikka et al. 2009) Overall in Taita Hills indigenous plant cover has decreased by 50% during the years 1950-2000. Total tree cover decreased only 2% during this period of time, however, because lots of exotic plant species have been planted to the area. (Pellikka et al. 2009)

2.2 Study area

The Taita Hills (03°20'S 38°15'E (Bytebier 2001)) form the northernmost portion of The Eastern Arc Mountains together with Mount Sagala and Mount Kasigau. As The Eastern Arc Mountains do not extend further north from Taita Hills, Taita Hills are the only hilltops inside Kenya's borders belonging to this ancient chain of mountains. Like the rest of the mountain chain on Tanzania's side, Taita Hills accommodate a vast number of endemic species in both flora and fauna. (Bytebier 2001)

In this study there were three smaller study areas inside Taita Hills (Fig. 5). Fifteen household interviews were conducted in each of the study areas totaling up in forty-five interviews. Households interviewed were chosen randomly and GPS data was taken from each interview to better see where they took place afterwards. The maps shown in Figs. 5 & 6 have been made based on these GPS dots. In the first image, these dots can be seen against a map and in the second image the dots can be seen against satellite imagery (Google Earth, image taken 2012). Mwanda study area is located further away from the two other study areas that are situated quite close-by.

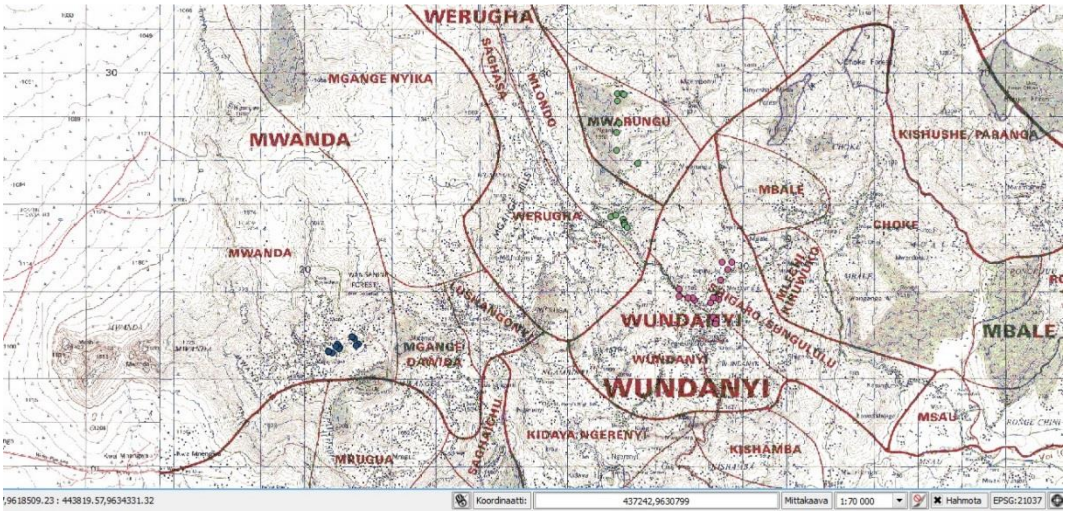

Figure 5. Map of the three study areas. Pink dots represent Wundanyi study area, green dots Ngangao study area and blue dots Mwanda study area. Scale of the map is 1:70 000.

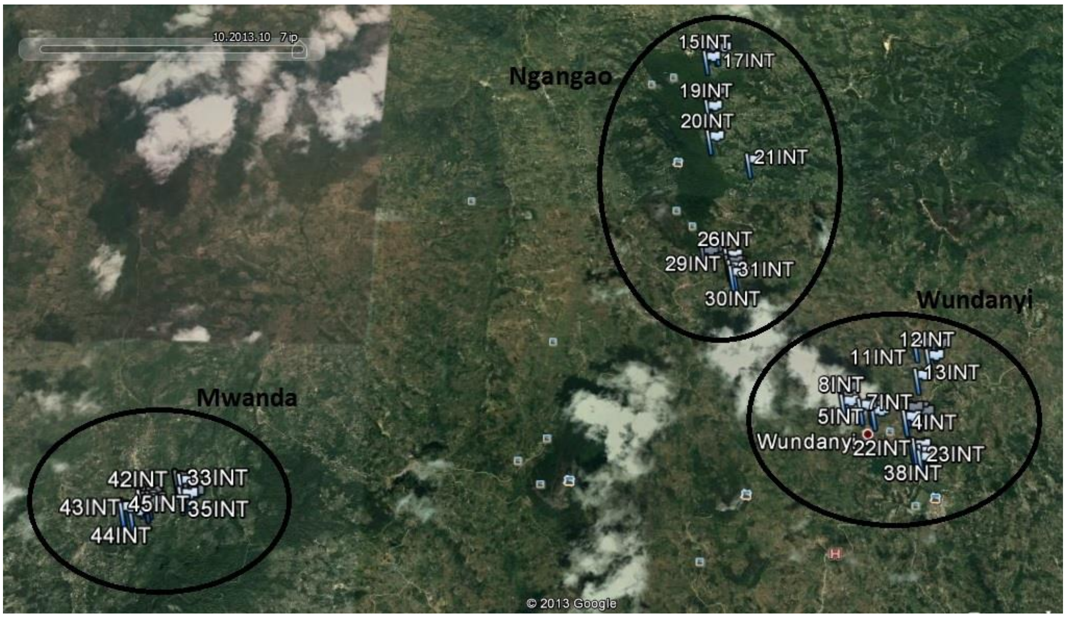

Figure 6. Satellite imagery of the three study areas: Wundanyi, Ngangao and Mwanda. Fifteen interviews were conducted in each of the study areas.

2.2.1 Wundanyi, Ngangao and Mwanda study areas

The three smaller study areas were chosen in an attempt to get slightly different kinds of environments included in the study. The first study area is located near Wundanyi center and it represents “urban” area. The second study area can be found near Ngangao forest, a government owned large forest area. The third and last study area is situated in Mwanda, which is a small village in western Taita Hills surrounded by small, community managed forest patches. The three study areas represent different kinds of environments e. g. in regards to elevation and closeness to forest. These values (average, min, max) of different attributes in the three study areas have been compiled to one table for clarity (Table 1). Highest values of each category can also be seen from the table (bolded). For instance, the average age of respondents was highest in Mwanda study area.

As mentioned, Wundanyi study area was the “urban” area of this study; Wundanyi town is the capital of the whole Taita Taveta district. Aerial photograph taken from the study area shows where the interviews took place (Fig. 7, green dots). The location of the research station is marked as a red dot. The average elevation of Wundanyi study area was the lowest elevation value amongst the three study areas. The respondents of Wundanyi study area also visited forests the least often.

Table 1. Values of elevation, age of respondents, household size, farm size, forest visiting habits and gender distribution in the three study areas. Highest values of each category have been bolded.

	elevation (m)	age (years)	household size	farm size (ha)	forest visiting (times / month)	males / females
Wundanyi						
average	1370	42.7	5.6	0.25	2.33	4 / **11**
min	*1290*	*16*	*2*	*0.08*	*0*	
max	*1434*	*70*	*10*	*0.77*	*12*	
Ngangao						
average	1701	38	**6.2**	**1.75**	**7.84**	**10** / 5
min	*1646*	*18*	*2*	*0.08*	*0*	
max	*1805*	*64*	*9*	*2.1*	*30*	
Mwanda						
average	**1720**	**44.2**	4.3	0.46	3.56	6 / **9**
min	*1692*	*21*	*1*	*0.08*	*0*	
max	*1747*	*77*	*10*	*2.02*	*8*	
average all areas	1597	41.6	5.4	0.6	4.58	20 / **25**

Interviews in Ngangao study area took place in the eastern and southern sides of Ngangao forest (Fig. 8, blue dots). These were the humid sides of the forest due to the rain shadow phenomenon discussed earlier in chapter 2.1. The average elevation of Ngangao study area was significantly higher than in Wundanyi study area and the maximum elevation of 1805 m in Ngangao was the highest elevation in all three study areas. Ngangao study area was situated next to Ngangao forest and many of the interviews, especially in the eastern side of the forest, were conducted in the immediate vicinity of forest (Fig. 8). Respondents in Ngangao study area visited forests most frequently amongst the study areas and the average farm size there was also the highest of all three study areas.

Figure 7. Interview locations can be seen as green dots in the aerial imagery. The red dot shows the location of the research station. Scale of the map is 1:10 000.

Mwanda study area was situated in the western Taita Hills. Red dots show the places where interviews were conducted in Mwanda study area (Fig. 9) although some of the dots are missing due to malfunction of GPS device during the last interviews. The missing dots would be situated close to the existing ones and therefore the existing dots give a good overview of the interview area, however. The average elevation in Mwanda study area was the highest of all three study areas.

Figure 8. Blue dots represent locations where interviews were conducted in Ngangao study area. Scale of the map is 1:10 000.

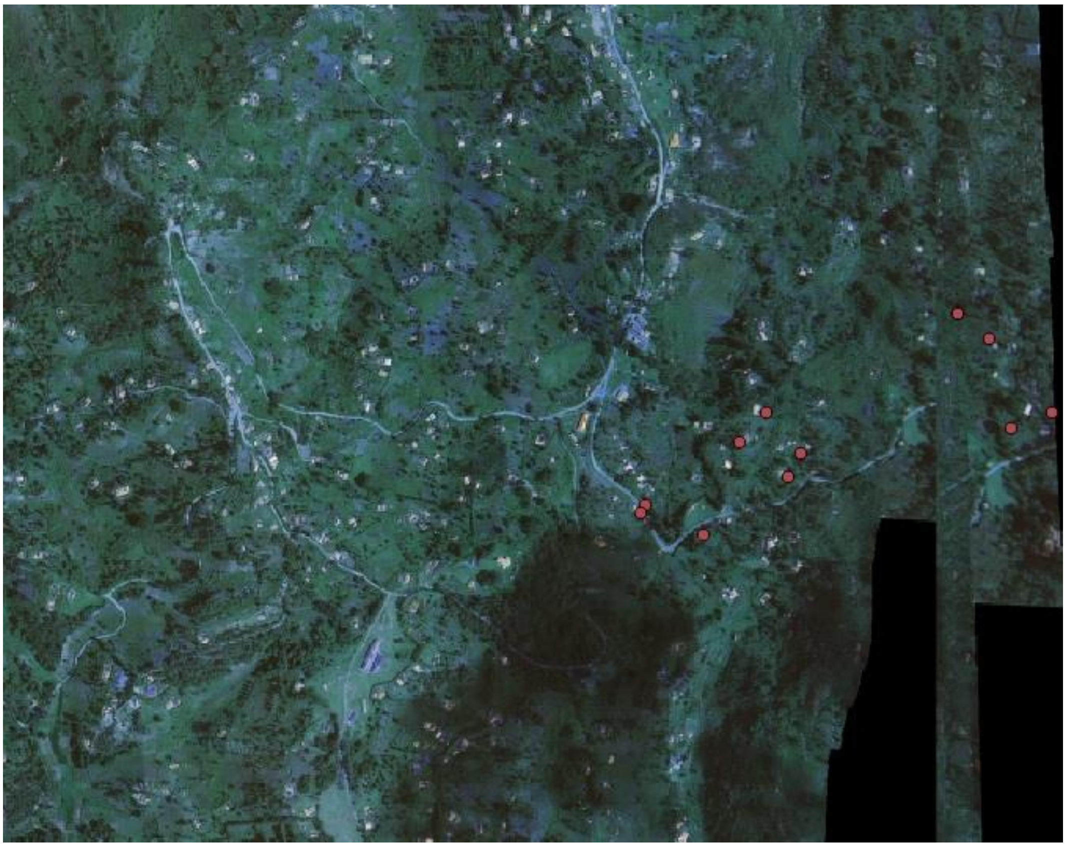

Figure 9. Red dots represent interviews conducted in Mwanda study area. Scale of the map is 1:10 000.

3. Ecosystem services

The scientific field of ecosystem services is still fairly young but the idea of nature being able to help people in moments of need was probably a familiar notion already to our first ancestors (Daily 1997b). In his book *Fundamentals of Ecology* Odum (1971) discusses the idea of ecosystem services linked to agriculture and forestry. He states that a person owning farmland or forest “must now consider “his” crops and forests have outputs other than food and fiber in terms of man’s total ecosystem” (Odum 1971, p. 411). The first two editions of his book were published in 1950s and the same idea was presented in them (Vihervaara et al. 2010) making Odum (1971) one of the first people to treat the subject of ecosystem services scientifically. The actual concept of ecosystem services was invented and introduced to the scientific world in the 1970s (Vihervaara et al. 2010). Since then interest in the subject and research on ecosystem services has been increasing steadily and it has become a popular theme in science during the last decades (Fisher et al. 2009). The real kick start for the field, however, was the Millennium Ecosystem Assessment published in 2005 (Schneiders et al. 2012; De Groot et al. 2010). The Millennium Assessment (hereafter MA) was coordinated by the United Nations and carried out between 2001 and 2005. The objective of MA was to assess human's impact on ecosystems globally and study how these impacts affect human well-being. Findings of MA were considerable and proved that humans have changed their environment substantially, especially during the last 50 years. (MA 2005a) These changes have mostly benefited human well-being but they have often been achieved at the cost of ecosystem well-being. Degradation of ecosystems generally leads to degradation of ecosystem services, which in the long run also affects human well-being negatively. This observation that degradation of ecosystems and biodiversity could lead to a loss of ecosystem services as well was one of the key findings of the whole MA (Atkinson et al. 2012). Nowadays one of the most important aspects of ecosystem services is considered to be their ability to justify nature conservation in a new, anthropocentric way where the actual, concrete benefits to humans can be taken into account (Lamarque et al. 2011).

After MA the number of publications concerning ecosystem services has increased rapidly (Fisher et al. 2009; Vihervaara et al. 2010) and the scientific field of ecosystem services is constantly growing. Fig. 10 displays the number of publications found from ISI Web of Science in the years 2001-2013 using the entry words "ecosystem services". Data for the graph was taken from ISI Web of Science in June 2014 (18.6.2014). Fig. 10 shows that the number of publications concerning ecosystem services has steadily risen after 2005 when MA was conducted, and in 2013 the number of publications skyrocketed to over 5500 publications compared to the 1800 publications in 2012. A new scientific journal "Ecosystem Services", launched in 2012, further emphasizes the growing interest in the field.

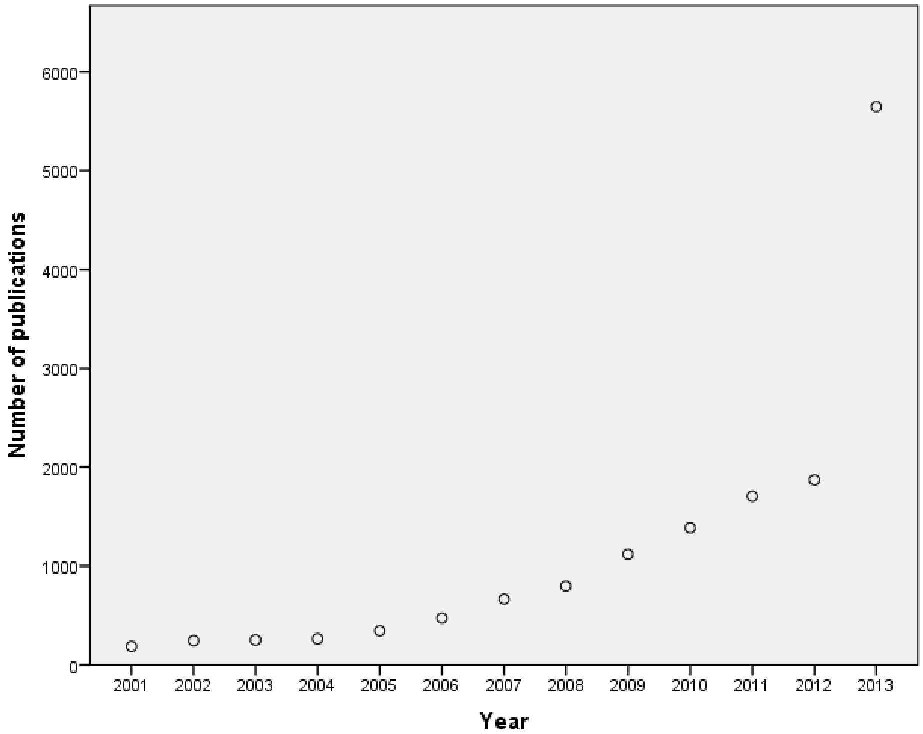

Figure 10. The number of publications concerning ecosystem services is rapidly rising (data taken from ISI Web of Science 18.6.2014 with the entry words "ecosystem services").

3.1 The varying definitions of ecosystem services

There are lots of differing definitions of ecosystem services out there (Wallace 2007, Lamarque et al. 2011). In this study five of these definitions are examined more closely and compared with each other to shed some light on ecosystem service research (Table 2). In order to be able to use the results of different ecosystem service studies around the world and compare them with each other, a coherent definition of ecosystem services is required. Unfortunately, the field of ecosystem service research is filled with other difficult definitions as well; terms such as "biodiversity", "ecosystem process" or "human value" are at least equally hard to define unequivocally and coherently as the term "ecosystem service" itself (Wallace 2007). There are also lots of different definitions for terms like "intrinsic value" or "existence value" (Davidson 2013) which makes it even more difficult to compare studies and talk about the same things not only by written terms but also by their meaning. These difficulties of understanding impair the usage of the term and can lead to a slowdown in nature conservation projects and sustainable resource use (Lamarque et al. 2011). It would therefore be important to try and create a uniform definition of ecosystem services so it could be consistently used in actual on-the-ground projects.

There is much discussion in science whether to include natural processes in the definition of ecosystem services (Wallace 2007). According to some scientists processes such as pollination or water filtration are services themselves (Fisher et al. 2009) while others claim they are only *means* to achieve services and cannot be singly counted as such (Wallace 2007). Some studies also claim that mere functions of ecosystems cannot be used to assess benefits because human inputs such as labour and infrastructure should also be taken into account (Lamarque et al. 2011).

The point at which a service becomes a service is also discussed. Some definitions (MA 2005c) find fodder production and water filtration as basic ecosystem services while other definitions (Wallace 2007) consider this double-counting and count services only when they directly provide something to people (in this case when human eats the animal fed with fodder or drinks the filtered water). The latter definition is highly human-oriented and ignores any intrinsic value an environment may behold. Intrinsic values are difficult, if impossible, to define unequivocally as they are so subjective and it is widely agreed that they cannot be incorporated into ecosystem services because of this (Davidson 2013). Exceptions exist, though; e. g. Raymond et al. (2009) include intrinsic values in the category of cultural services.

One of the first studies to estimate monetary values of ecosystem services in a global scale was a study by Costanza et al. in 1997. Later, it was widely criticized for using improper monetary values (Ninan & Inoue 2013) but this study presented one of the first definitions of ecosystem services in science. Costanza et al. (1997) define ecosystem services as “the benefits human populations derive, directly or indirectly, from ecosystem functions” (Costanza et al. 1997, p. 253). According to Costanza et al. (1997) ecosystem services are the benefits produced by ecosystem functions, not the functions themselves. The focus of their definition is in human reception of services, not the production of them.

Ecosystem services have also been defined from a more nature-oriented viewpoint. According to Daily (1997a) ecosystem services are "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997a, p. 3). The angle of approach is opposite to the definition by Costanza et al. (1997) because Daily (1997a) defines ecosystem services as ecosystem functions, not the benefits produced by them. According to Daily (1997a) the benefits produced by ecosystem services are called ecosystem goods (e. g. fruits or timber). In conclusion, Costanza et al. (1997) state that ecosystem services are the benefits produced by ecosystem functions and Daily (1997a) states that ecosystem services are the ecosystem functions that then produce ecosystem goods. Both definitions accentuate the human aspect, though, as they both strongly state that ecosystem services are something that profit humans.

The MA in 2005 by the United Nations was a turning point for the whole research of ecosystem services (De Groot et al. 2010; Schneiders et al. 2012). MA's definition of ecosystem services is still widely accepted and used (Derissen & Latacz-Lohmann 2013), also as a baseline for newer definitions. MA defines ecosystem services simply as "the benefits people obtain from ecosystems" (MA 2005c, p. 53). It is a vast, human-oriented definition that declares all benefits as services (Fisher et al. 2009). This definition of ecosystem services by MA was not independently created, however. It was based on two other largely used definitions before MA: the above-mentioned definitions by Costanza et al. in 1997 and Daily in 1997 (MA 2005c). MA combined these two differing definitions and developed one, vaster definition out of them. MA's definition of ecosystem services does not specify if the benefits people obtain from nature need to be functions or goods; anything that can be understood as a benefit counts.

Take water retention for an example. With the Daily (1997a) definition water retention would be an ecosystem service as it is a process of nature that produces ecosystem goods for people. With the Costanza et al. (1997) definition water retention itself would not be an ecosystem service but the crops grown with the help of this water and then eaten by humans would count as one. According to MA (2005c) the water retention would be an ecosystem service as it benefits people by allowing them to cultivate land. These three authors have differing views on what part of the nature is the actual ecosystem service. Is it the process or the benefit obtained from it? Can a process be a benefit in its own right? Newer definitions of ecosystem services by e. g. Boyd & Banzhaf (2007) and Fisher et al. (2009) have been trying to solve these issues by describing ecosystem services even more specifically.

In their definition of ecosystem services Boyd & Banzhaf (2007) focus on the human well-being as an outcome with a concrete approach. According to Boyd & Banzhaf (2007) "final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being" (Boyd & Banzhaf 2007, p. 619). This means that only directly used benefits are considered as ecosystem services and indirect benefits obtained from the ecosystems are not. It is therefore even more human-oriented definition than the ones by Costanza et al. (1997), Daily (1997a) and MA (2005c). If the water retention example is used here, it can be seen that water retention is just an indirect benefit to humans and the crops grown with the water and then eaten are the direct benefits. Water retention would not therefore be an ecosystem service according to Boyd & Banzhaf's (2007) definition.

One of the newest definitions of ecosystem services is the one by Fisher et al. (2009). They define ecosystem services as "aspects of ecosystems utilized (actively or passively) to produce human well-being" (Fisher et al. 2009, p. 645). This definition requires an ecosystem service to be an ecological phenomenon, not just something perceived as a benefit by humans (e. g. recreation). Indirect benefits are also counted as ecosystem services in this definition. Interesting idea posed by Fisher et al. (2009) is that these ecological functions are counted as ecosystem services only if there are humans who benefit from them – without humans benefiting from the functions they are not counted as ecosystem services (Fisher et al. 2009). Water retention example has two possible outcomes with this definition. Water retention is an ecological phenomenon so accordingly it would count as an ecosystem service. However, if there are no people to benefit from the phenomenon, it would not be counted as an ecosystem service. This means that in a populated area where land is cultivated or otherwise utilized water retention would be an ecosystem service according to Fisher et al. (2009) but in a natural area where there is no human activity it would not be one.

Table 2. Definitions of ecosystem services by different authors.

Author	**Year**	**Definition**	**Ecosystem services**
Daily	1997	"ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life"	ecosystem processes
Costanza et al.	1997	"the benefits human populations derive, directly or indirectly, from ecosystem functions"	benefits produced by ecosystem processes
MA	2005	"the benefits people obtain from ecosystems"	all benefits
Boyd & Banzhaf	2007	"final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being"	direct products produced by ecosystem processes
Fisher et al.	2009	"aspects of ecosystems utilized (actively or passively) to produce human well-being"	ecological processes utilized by human

These five definitions (Table 2) do not cover all the definitions made of ecosystem services in the scientific world but they do represent some of the most widely used definitions and offer slightly differing viewpoints on ecosystem services. One common factor that can be found in all five definitions is that they are focused on human well-being and describe a relationship between nature and human. Ecosystem services always profit human beings in some way, be it in a concrete, abstract or spiritual level. Differences can be found whether to include indirect benefits to the definition or not and how to define ecosystem services themselves (all benefits, final ecosystem services, only ecological aspects).

Definitions by Costanza et al. (1997) and by Boyd & Banzhaf (2007) both accentuate that ecosystem services are the final products and benefits produced by ecosystems. Daily (1997a) and Fisher et al. (2009) in turn consider ecosystem services to be the ecological processes of ecosystems. MA's definition is the broadest and it combines definitions by other authors. All these authors speak of ecosystem services even though they mean very different things with it. This is why it should always be mentioned in a study which definition has been used because otherwise its results are close to impossible to compare with other studies.

3.2 Classification of ecosystem services

Before ecosystem services can be classified it is important to define them clearly and consistently (Fisher et al. 2009). This can be problematic, though, as ecosystem services are often vast and multidimensional and there are many differing definitions of ecosystem services as was discussed above. Correspondingly with the complexity of defining what an ecosystem service really is the classification of them is also controversial between different authors. Three of these classifications are examined in this study (Table 3) and the basic idea of them all remains the same, though – ecosystem services are first divided into a few main categories and then into sub-categories of varying levels.

MA 2005

There are several different classifications of ecosystem services out there, but some are more widely used and accepted than others. According to many authors the most commonly used, though also criticized, categorization of ecosystem services is MA's classification (Vihervaara et al. 2010; Fisher et al. 2009). This classification is one of the first comprehensive categorizations of ecosystem services and it divides them into four categories: provisioning services, regulating services, cultural services and supporting services.

According to MA (2005b) provisioning services are direct benefits that people obtain from nature. They include services such as food, fiber, natural medicines and fresh water – concrete benefits produced by the nature. Some of these services, e. g. food and fiber, can further be divided into sub-categories such as livestock, aquaculture, timber or cotton. (MA 2005b) Provisioning services are very tangible and therefore easily valued also in monetary terms. Majority of provisioning services have a set market price and belong to the global market of goods.

Regulating services can be defined as processes and mechanisms of nature. Erosion regulation, air quality regulation and pollination are some examples of regulating ecosystem services defined by MA (2005b). Some of them can be sub-categorized into regional, local or global level services (MA 2005b). Regulating services are very hard to value in monetary terms because it is difficult to measure them reliably. They do not usually have fixed market prices but their value can be included in a price of goods. For instance if a big tree shades a house, the value of this regulating service can be seen in the price of heating or cooling required to keep the temperature appropriate.

Cultural services are always connected to humans' actions. They can be described as all sorts of different recreational, educational, spiritual or aesthetic benefits people derive from the nature. Examples of cultural ecosystem services are swimming, bird watching, relaxing and jogging in nature. In MA (2005b) classification, existence value is also one of the cultural services. Cultural services are difficult to value in monetary terms as they can be very subjective (e. g. spiritual experiences). Their valuation is actually considered as one of the least accomplished aspects in the field of ecosystem services (Barrena et al. 2014).

Supporting services work all the time on the “background”. They are “ecosystem services that are necessary for the production of all other ecosystem services" as styled in MA (2005b). Important mechanisms of nature such as photosynthesis, nutrient cycling and soil formation are counted as supporting services according to MA (2005b). Supporting ecosystem services are often categorized little aside from the three other service categories because they cannot properly be compared with them.

TEEB 2007

Another widely accepted classification of ecosystem services is the one by TEEB (The Economics of Ecosystems & Biodiversity). TEEB was initiated by European Commission in 2007 in Germany. Its later phases have also been initiated by United Nations Environment Programme (UNEP). TEEB’s classification of ecosystem services is almost similar with MA classification differing only with a few single services. One of the biggest differences is that in TEEB classification the fourth category is not named “supporting services” but “habitat or supporting services”. According to TEEB classification habitat provision is an important enough service to be part of the name of one of their service categories. One of TEEB’s goals in creating its classification system was to strengthen both biodiversity and ecosystem services (Schneiders et al. 2012) which could be a reason why it emphasizes the significance of the variety of ecosystems – one of the levels of biodiversity.

CICES 2009

A more recent classification of ecosystem services is CICES (Common International Classification of Ecosystem Services) which aims to create a standard classification system of ecosystem services on a global level. The idea of CICES embarked from a meeting hosted by the European Environment Agency in 2009 (Haines-Young & Potschin 2011). CICES only has three ecosystem service categories as opposed to both MA's and TEEB's four categories dividing services into "provisioning services", "regulating and maintenance services" and "cultural and social services".

Table 3. Ecosystem service classification systems.

Author	**Year**	**Categories**
MA	2005	provisioning, regulating, supporting, cultural
TEEB	2007	provisioning, regulating, habitat or supporting, cultural
CICES	2009	provisioning, regulating and maintenance, cultural and social

These three classifications (Table 3) are currently few of the most widely used ones. They have similarities but unfortunately they also have lots of contradictions with each other. CICES classification differs the most from the mutual line as it has only three categories as opposed to MA's and TEEB's four. In CICES classification the services belonging to MA's and TEEB's supporting (and habitat) services are mainly distributed between CICES's provisioning services and regulating and maintenance services categories. This creates confusion when different service categories are compared between studies as they no longer correspond.

The concept of ecosystem services should be possible to use by a wide range of stakeholders, e. g. scientists, policy makers and educators (Fisher et al. 2009). Problems of definition can confuse decision-making processes etc. as all parties may not understand there is such big variation in the meaning of the terms depending on which classification (or definition) has been used. Different stakeholders may also have different ideas about environment starting from the vocabulary they use to describe it. The challenging terminology surrounding the whole topic does not help when people from different backgrounds try to talk about the same thing.

3.3 Ecosystem services in this study

I felt the need to clarify the definition of ecosystem services used in this study because there are so many differing definitions out there. If the reader does not know according to which definition the study is written, the worst case scenario is that it is useless to him because he cannot reliably compare its results with other similar studies. With this in mind, I will clarify the definition and classification of ecosystem services used here before going any further into the subject.

The definition and classification of ecosystem services used in this study correspond with the definitions by MA (2005b); in this study ecosystem services are understood widely as all benefits people obtain from ecosystems as described by MA (2005c). The categorization also follows the categorization of MA (2005b), which means that there are four ecosystem service categories in this study: provisioning services, regulating services, cultural services and supporting services. Different levels of sub-categories of MA (2005b) are also used.

MA’s (2005c) definition of ecosystem services was selected to be the definition in this study because it is the first real categorization and systematic representation of ecosystem services. It has also been proved in earlier studies that MA’s (2005c) definition of ecosystem services corresponds well with the mindsets of regular people (Fischer et al. 2011). Practically all ecosystem service research of today is more or less based on MA (2005b) and it provides a good basic framework to start one’s assessment of ecosystem services. MA’s (2005c) definition and classification of ecosystem services is old enough to have survived the test of multiple peer reviews but still modern enough to reflect today’s ideas of ecosystem services and their ecological basis. Because of these aspects it is an ideal definition for this master’s thesis level study.

3.4 Africa, the continent of diverse ecosystem services

People tend to use different ecosystem service categories differently around the world. It is acknowledged that in developing countries people depend the most on provisioning services, e. g. firewood, poles for construction, wild animals for food and water for drinking (Egoh et al. 2012). There has been some research concerning ecosystem services of Africa but the research has been concentrated on certain areas of the continent, and it is not evenly distributed. Most of the ecosystem service research conducted in Africa has been completed in South Africa (Egoh et al. 2012).

The varying climatic conditions and vegetation cover of the continent of Africa affect ecosystem services produced there. In humid western and central Africa food, raw materials and agriculture form the basis of important ecosystem services while in drier southern and northern Africa tourism, water and grazing are more central in the livelihoods of people. (Egoh et al. 2012) Medicinal plants have been widely used all around Africa for curing different kinds of sicknesses and ailments for a long time, partly because there have not been enough easily accessible hospitals and other medical facilities around (Egoh et al. 2012) and partly because the environmental conditions are very suitable for growth of medicinal plants. Their usage is an important ecosystem service in Africa.

Agriculture is a common source of livelihood in Africa. In fact, it is a popular source of livelihood in the entire world as over 25 % of Earth's land surface is used as crop or rangelands (Swinton et al. 2007). In Taita Hills, agriculture is one of the most important sources of livelihoods (Himberg 2011). Agriculture is strongly linked to ecosystem services as well; it uses and produces multiple ecosystem services and disservices (Zhang et al. 2007). Farmers depend on a multitude of ecosystem services such as regulating services linked to soil fertility, water supply, erosion control and pest control. The fertility of soil is essentially achieved by an important supporting service, soil formation. It is actually considered one of the most important ecosystem services in Africa. (Egoh et al. 2012) Ecosystem services linked to agriculture have been studied and assessed in many studies. Swinton et al.

(2007) and Zhang et al. (2007) identified different kinds of disservices linked to agriculture. Disservices can be understood as negative ecosystem services or as disadvantages provided by ecosystems. Some of these disservices as well as normal ecosystem services linked to agriculture can be seen in Fig. 11. Nature does not only provide beneficial things to people but also hurts them in many ways. In the frame of ecosystem services these things are usually left aside, however, because the purpose of ecosystem service research is to study human well-being through positive influences of nature. Nevertheless, it should be remembered that there are also negative aspects of ecosystems (in regards to human well-being) and they can be closely linked to ecosystem services.

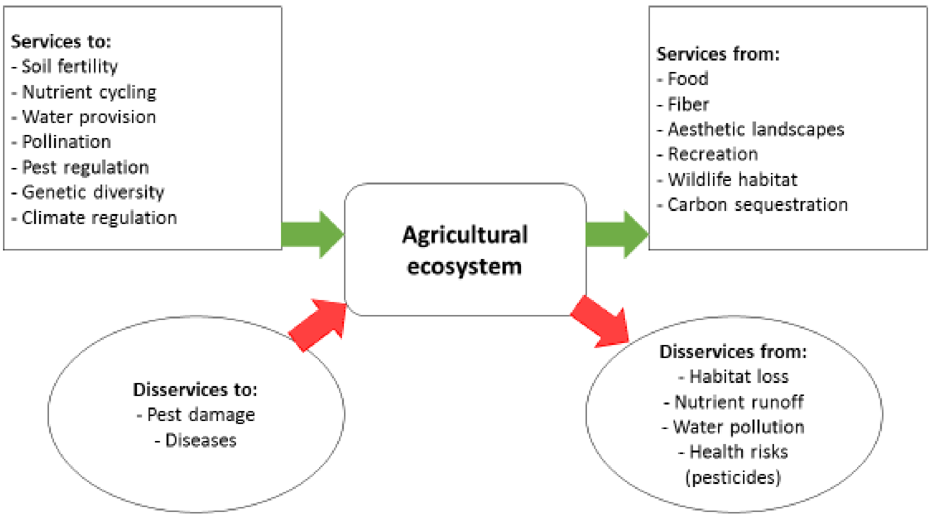

Figure 11. Ecosystem services and disservices related to agricultural ecosystems. (edited by E. Tuomaala (2014) from Swinton et al. (2007) and Zhang et al. (2007))

Fig. 11 has been edited from figures by Swinton et al. (2007) and Zhang et al. (2007). It describes different ecosystem services and disservices related to agriculture and portrays well how multidimensional ecosystems really are. It can be seen in Fig. 11 that ecosystem services needed for agriculture are mostly regulating services such as climate regulation or pollination. Ecosystem services provided by agriculture, in turn, belong to all four ecosystem service categories varying from food and fiber to aesthetic and recreational values. It would therefore seem that through agriculture people can alter the natural, unaffected ecosystem services provided by nature and broaden their spectrum. It can also be seen that agriculture can have harmful consequences to both people and nature, too. Water pollution and health risks resulted from the usage of pesticides and fertilizers in agriculture can counteract some of the benefits obtained from it.

4. Biodiversity

Another term that needs to be defined before it can be used in this study is biodiversity. Biodiversity is an abbreviation of the words biological diversity and basically describes the diversity of all living things at planet Earth. The term can be used differently by different people (Fisher et al. 2009) making the list of intangible terms surrounding the field of ecosystem services even longer.

There are three main levels of biodiversity: genetic diversity, species diversity and ecosystem diversity. Genetic diversity describes genetic variation within and between populations. It is the "smallest" scale of biodiversity and creates a basis for the two other levels. Species diversity is publicly the most familiar level of biodiversity and also the level that is often directly paralleled with the term biodiversity (Feld et al. 2009). It describes the variety of species in the biosphere and is easy to comprehend as everybody can differentiate most species from each other. Ecosystem diversity is the vastest level of biodiversity. It describes the diversity of all ecosystems in the biosphere. Differing abiotic conditions such as climate and topography allow the Earth to sustain lots of different ecosystems around the world. Ecosystem diversity describes and examines these ecosystems and their interactions with each other. (Campbell et al. 2008)

''The total value of biodiversity is infinite so having a debate about what is the total value of nature is actually pointless because we can't exist without it.''
(Robert Scholes, ecologist).

The value of biodiversity is another subject that has been debated a lot (Salles 2011). It is difficult to appoint economic value to something as abstract and subjective as biodiversity even though it is obvious that it is important for all human beings as Robert Scholes describes above. Perhaps the easiest way to analyze the monetary value of biodiversity is to look at ecosystem services it provides and enables, calculate their monetary values and sum them up. In order to do this, however, different ecosystem services need to be understood well enough to be able to see what their individual monetary values are. This leads to a problem that some ecosystem services are easier to value in monetary terms (e. g. firewood) than others (e. g. scenery). Lack of knowledge might distort the economic value of biodiversity even more than that of individual ecosystem service as the value of one ecosystem service is only part of the total value of biodiversity.

The research of biodiversity's effects on ecosystem functioning, e. g. ecosystem services, has been increasing quickly during the last decade (Srivastava & Vellend 2005) mimicking the increase in ecosystem service research. The two research themes support each other to some extent as they both study ecosystem functioning, even if ecosystem services can be studied in many ways that have nothing to do with biodiversity. The terms are more intertwined than separate, however. It is commonly believed that biodiversity is a prerequisite for maintaining ecosystem functioning (Srivastava & Vellend 2005) and therefore a necessity also for the production of ecosystem services.

Intensification of land use has affected biodiversity in the past decades and contributed to its decline (MA 2005a). Biodiversity loss and human well-being are correlated according to many studies (MA 2005a; Diaz et al. 2006) which suggests that along with the decline of biodiversity the overall human well-being has decreased as well. There is also a linkage between biodiversity and ecosystem services (Schneiders et al. 2012). Many studies claim that this linkage is positive meaning that biodiversity loss leads to a loss of ecosystem services and vice versa (Diaz et al. 2006, Hooper et al. 2005); in a diverse environment there are more species that have the possibility to produce different kinds of ecosystem services.

There is evidence that not all ecosystem services correlate with biodiversity, though. Regulating and supporting services correlate with biodiversity quite well but some provisioning services, especially food production, do not (Schneiders et al. 2012). Agriculture often reduces biodiversity of the area, especially if monoculture is used as an agricultural practice. Even in more diversely cultivated farms biodiversity is usually lower than in the surrounding areas making biodiversity and ecosystem services correlate negatively in the case of food production. In this case biodiversity can actually affect ecosystem services negatively contrary to popular belief. This needs to be kept in mind when assessing the situation of Taita Hills, too, where agriculture is a main source of livelihood.

As biodiversity and ecosystem services do not correlate completely there might be a situation where maintaining or enhancing one ecosystem service leads to a decline in the part of biodiversity that is not required to produce the service in question (Hooper et al. 2005). This decline in biodiversity can in turn lead to deterioration of other ecosystem services in the area. Partly because of this difficulty in specifying which parts of the environment are the most important in bigger picture, precautionary principle is generally used to protect ecosystems and the services they provide (Ridder 2008). It is also known that the more there are species that have different functional characteristics in an ecosystem, the more resilient it is against changes (Schneiders et al. 2012). This promotes the role of biodiversity in preserving and producing ecosystem services.

4.1 Biodiversity hotspots of the world

There are around 30 biodiversity hotspots in the world at the moment. Environment is constantly changing and evolving through both natural and anthropogenic mechanisms, and the number of biodiversity hotspots varies according to these changes. The definition of a biodiversity hotspot also affects their numbers. The 25 biodiversity hotspots defined by Myers et al. in 2000 give a pretty good view of the biodiversity hotspots of today as well. Even if their study is 14 years old it is still cited in many studies of today concerning biodiversity, e. g. by Edwards et al. (2014), Postaire et al. (2014) and Schut et al. (2014).

In 2014, Conservation International listed 35 places around the world to qualify as biodiversity hotspots. Their definition of a hotspot is quite similar to the definition of Myers et al. (2000). Conservation International defines biodiversity hotspot as an area that has at least 1500 endemic vascular plants and has only 30% or less of its original vegetation left (Conservation International 2014). The 35 areas qualified as biodiversity hotspots according to Conservation International in 2014 cover only 2.3% of Earth's land surface area.

The definitions of biodiversity hotspots by Conservation International and Myers et al. (2000) can be seen side by side in Table 4. They are quite similar even though the gap between the definitions is 14 years which means the concept of biodiversity hotspots is well established. The basic idea of a biodiversity hotspot is that the area in question meets two criteria: 1) it sustains a lot of endemic plant species and 2) it is threatened in some way. Interestingly the number of endemic animal species (or any species except plants) is not taken into account in the basic definition of a biodiversity hotspot.

Table 4. Definitions of a biodiversity hotspot by two authors.

	Myers et al.	Conservation International
Year	2000	2014
Criteria for the area in question	1) must have endemic plant species that comprise at least 0.5% of all plant species world-wide 2) has lost 70% or more of its original vegetation	1) must have at least 1500 endemic vascular plants 2) has only 30% or less of its original vegetation left
Earth's land surface	1.4%	2.3%
Number of hot-spots in the world	25	35

4.2 Keystone species are “administrators” of their ecosystems

Some studies argue that the provision of many ecosystem services is based on just a few specific species (Ridder 2008) or a certain functional group of species (Hooper et al. 2005). The concept of keystone species becomes important here. A keystone species is a species that has a crucial role in an ecosystem and affects greatly the way it functions. There are often only a few species in a community that have big influence to its function while the rest of the species are rarer and mostly contribute to the total diversity of the community (Odum 1971). This early definition of keystone species is still understood pretty much the same way: keystone species are not necessarily abundant in an ecosystem but they strongly affect its community structure through their ecological roles in it (Campbell et al. 2008). If a keystone species would be removed from its ecosystem, the ecosystem would function in a totally different way or even cease to exist.

Typical examples of keystone species are predators and ecosystem engineers. Predators control their environment by affecting a large number of lower trophic level species even when the predators themselves represent only a small portion of the whole ecosystem. Ecosystem engineers in turn are species that greatly alter their environment just by living there, such as beavers or woodpeckers. The dams made by beavers can transform whole forest ecosystems into wetlands and the holes made by woodpeckers offer habitats for a multitude of insects etc.

4.2.1 Are there keystone species for ecosystem services, too?

Some species contribute more to the production of ecosystem services than others (Ridder 2008, Hooper et al. 2005) and can therefore be seen as keystone species of ecosystem services. For example timber production often concentrates on a few specific tree species that have better quality wood than others. These species can be seen as keystone species of timber production (a provisioning service) as they contribute more to the human well-being gained from ecosystem than other species.

4.3 Urbanization and perceptions of biodiversity

Urbanization is often considered a threat to biodiversity (Shwartz et al. 2014, Wu 2010). Isolation from nature due to urbanization is one of the key arguments for this as people's attitudes towards nature also affect their willingness to protect and conserve it (Shwartz et al 2014), and conservation strongly depends on the value people give nature (Lindemann-Matthies et al. 2010). Isolation from natural environment is worrisome also because exposure to nature is increasingly considered to enhance human well-being (Dallimer et al. 2012). Exposure to nature is associated with a number of positive phenomena nowadays, e. g. stress alleviation (Yamaguchi et al. 2006), increased social interaction (Sullivan et al. 2004), improvement in both physical and mental health (Mitchell & Popham 2008, Kaplan & Kaplan 1989), and even lower crime rates (Kuo & Sullivan 2001).

In terms of area urban regions cover only 3% of the Earth's land surface (Wu 2010). They accommodate more than half of the world's population, though; in 2011 52.1% of the world's population lived in urban areas (United Nations 2012). In Africa, this percentage was 39.6% which means that most people still live in rural environments there. In Kenya, only 24% of the population lived in urban areas in 2011. (United Nations 2012) The assumed threat of urbanization to biodiversity would seem to be lower in Kenya than in the world in average which may also have affected the formation and survival of the biodiversity hotspot in Taita Hills.

People's perception of biodiversity has been studied a lot, especially in urban environments (Shwartz et al. 2014, Dallimer et al. 2012). Understanding people's perception of biodiversity is necessary to truly understand diversity's role in people's lives (Shwartz et al. 2014). Some of the main findings of these studies have been that people's perception of biodiversity affects their well-being more than the actual changes in biodiversity (Dallimer et al. 2012, Shwartz et al. 2014) and that some forms of biodiversity affect human well-being more than others (Fuller et al. 2007). Dallimer et al. (2012) also stated that people often have weak biodiversity identification skills and that they recognize only some components of biodiversity, such as plants. Plants' role in biodiversity is important to people due to their attractiveness (Lindemann-Matthies et al. 2010) and the fact that they often are the most visible and stationary components of nature (Fuller et al. 2007) making them an important factor in people's conception of biodiversity. Fuller et al. (2007) stated that certain plant species had a bigger effect on people's well-being than e. g. birds and butterflies. This promotes the capability of the study species of this study to reflect respondents' conception of biodiversity as well because they consist of ten plants and one lichen.

The conception that especially plants are an important part of biodiversity correlates well with the definition of biodiversity hotspots. According to both Conservation International (2014) and Myers et al. (2000) the first criterion of a biodiversity hotspot is that an area has enough endemic plant species. Neither of the definitions mention any species apart from plants to affect an area's qualification as a hotspot so people's conception that plants are important fits the definition well.

As people's awareness of their environment affects their willingness to protect it, it has been suggested that a sheer provision of information could be an important factor in reconnecting people to nature (Shwartz et al. 2014). There have also been claims, however, that no amount of education can change people's perception of nature unless it takes their existing basic values into account (Fischer et al. 2011). Dallimer et al. (2012) stated that people's awareness of biodiversity is quite low in average. In their study there was no consistent correlation between human well-being and the actual species richness, and well-being even decreased when plant species richness increased at some cases. However, people's conception of the biodiversity affected their well-being evidently. This suggests that people may have low biodiversity recognition skills but they do have an idea of what biodiversity is to them – and that conception affects their well-being, too. Therefore it is important to recognize the factors from the environment that make people think the biodiversity is high because it can help in the conservation of nature.

Biodiversity is such a vast concept that it might be difficult to analyze certain aspects of nature that correlate with high biodiversity with everyone. The valuation of biodiversity happens for an ample number of reasons and people's background may also affect this valuation process (MA 2005a). As the number of people living in urban areas is steadily growing the gap between humans and natural environments widens all the time (Dallimer et al. 2012). This means that people's lives have less and less to do directly with nature and it might also affect their understanding of biodiversity.

Even though biodiversity is quite well defined and understood in scientific terms its meaning to regular people and their conception of biodiversity is less studied and understood (Fischer et al. 2011). At the moment biodiversity is scientifically understood as genetic variance within and between species, the number of different species or the number of different ecosystems. There are certain indicators that can be studied in order to research biodiversity (e. g. birth and death rates in a population) but it might be necessary to come up with some new indicators in order to better understand people's attitudes towards biodiversity and nature (Dallimer et al. 2012). In general, people tend to appreciate plants and especially tree cover in their environments and consider this as an indicator of high biodiversity (Dallimer et al. 2012). When studying people's perception of biodiversity, value, harmfulness and attractiveness of an individual species have been noticed to be the most important aspects regarding the desirability of a spesicific species. On the other hand nativeness, vulnerability and rarity that often are used as arguments in decision-making processes are not that important in people's perceptions. (Fischer et al. 2011)

Aesthetics seem to play a big role in people's perception of biodiversity; attractiveness was one of the most important aspects of a single species in terms of its desirability (Fischer et al. 2011) and in addition to plants people associate the number of birds and butterflies with biodiversity (Dallimer et al. 2012). Aesthetics is one of the aspects of biodiversity that isn't understood that well in science. It is known that biodiversity is important for the functioning of ecosystems but it is less understood how important biodiversity is when it comes to aesthetic values (Lindemann-Matthies et al. 2010). The studies described above seem to indicate, however, that aesthetics is an important factor in the well-being biodiversity produces – charismatic and beautiful species seemed to produce more human well-being than small and unremarkable species.

4.4 Biodiversity as a source or threat to ecosystem services

The concept of biodiversity is interesting when it comes to ecosystem services. According to MA (2005b) the role of biodiversity in regards to ecosystem services is not clear; in some cases biodiversity can be seen as an ecosystem service itself (e. g. regulation of diseases, basis of ecotourism) but it is also a necessary condition for the existence of other ecosystem services. In the latter case biodiversity's role resembles the definition of supporting services, "ecosystem services that are necessary for the production of all other ecosystem services" (MA 2005b). Based on the examples given above, biodiversity can be considered to belong to either regulating, cultural or supporting services. It can also be considered to be a feature of nature that does not belong to any ecosystem service categories but affects them from outside. Biodiversity can also be seen to have intrinsic value which makes it inadequate to fit the definition of ecosystem services (Davidson 2013). On the other hand its existence value puts it back to the category of cultural services. In some cases biodiversity can also deteriorate certain ecosystem services as was discussed above in chapter 4. Altogether, there is no clear understanding as to how to determine biodiversity's role when it comes to ecosystem services.

The interactions between biodiversity and ecosystem services have been studied a lot (MA 2005a, Hooper et al. 2005). Regulating services have been identified to need biodiversity more than provisioning services (MA 2005a). The same observation was made by Schneiders et al. (2012) who stated that regulating and cultural services are more dependent on biodiversity than provisioning services.

4.5 Biodiversity of Africa and The Eastern Arc Mountains

The Eastern Arc Mountains consist of 13 separate mountain blocks situated in Tanzania and Kenya (Burgess et al. 2007). Only one of these blocks, Taita Hills, is situated inside Kenyan borders (Fig. 12).

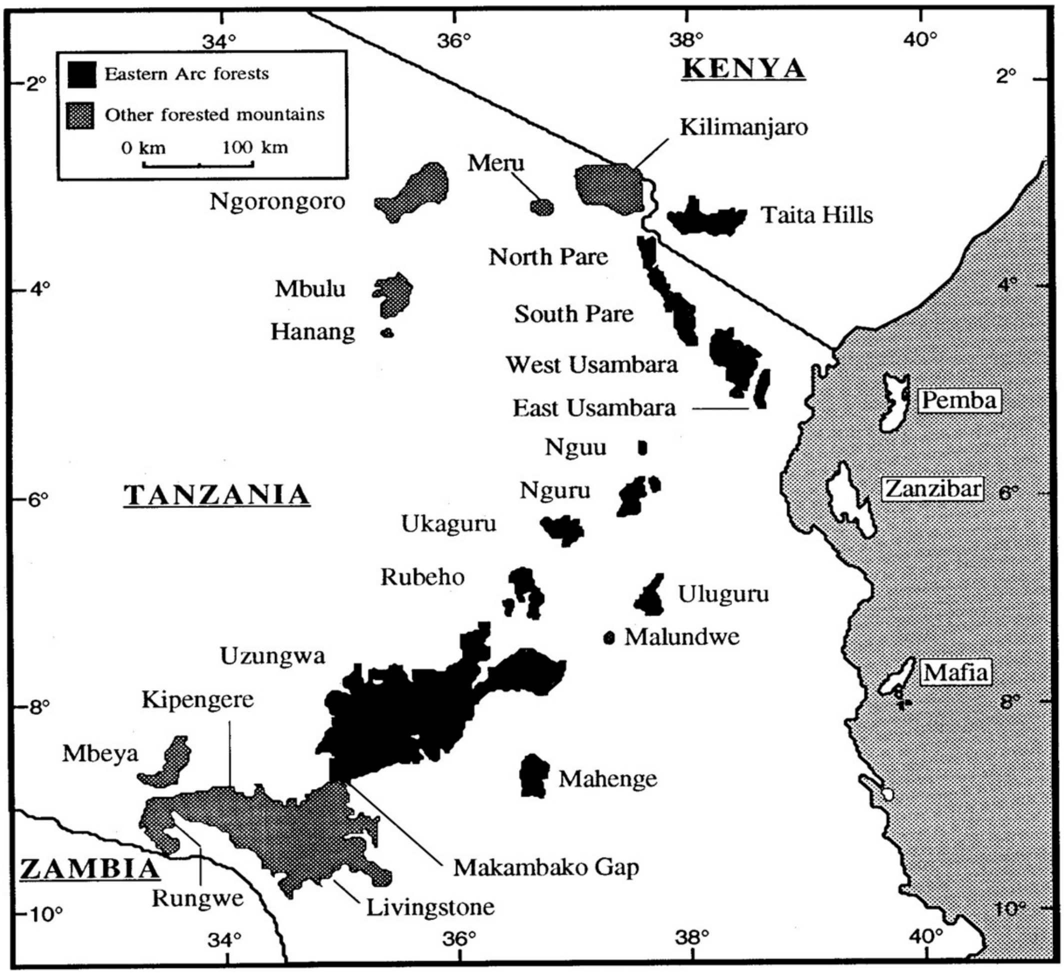

Figure 12. Map of the 13 blocks belonging to The Eastern Arc Mountains. (Burgess et al. 2007)

The Eastern Arc Mountains are one of the world's 25 biodiversity hotspots. In the continent of Africa there are six biodiversity hotspots in total (according to the classification by Myers et al. (2000)). The island of Madagascar, Western African Forests, Cape Floristic Province and Succulent Karoo in South Africa and the coastline of the Mediterranean Sea are also considered as biodiversity hotspots of the world. Most of the biodiversity hotspots are found near the equator as can be seen from the map in Fig. 3, which is the case with Taita Hills, too – they are situated only approximately 350 km from the equator.

Being such a vast continent Africa provides diverse environments for different kinds of organisms. Despite this diversity of surroundings, however, more than 50% of African communities live in rural regions (Egoh et al. 2012). Many of the most pristine environments left in the world can be found in Africa due to its slow development in industrialism. Fast urbanization of developing countries poses a real threat to these environments and makes Africa one of the focus areas of conservation.

4.6 Introduced species

Introduced species are species that are not native to the area and have been brought there by someone at some point of history. Along with the increase of human mobility invasive species have been able to leave their isolated habitats and spread around the world (Young 2010). Introduced species can divide people's opinions; they can be considered positive and "exotic" by some people or negative and "intruding" by others (Fischer et al. 2011). There is no clear understanding of the goodness of introduced species overall. Introduced species, alien species, exotic species, non-native species and invasive species are all more or less synonyms with each other meaning the same thing – a species that is not native to the area in question. In this thesis all these terms have been used objectively and they mean the same thing but some people probably choose carefully which term to use depending on the context – *invasive* or *alien* have a much more negative connotation in them than *exotic*, which might even have a positive connotation to some people.

There is more research and knowledge about the adverse effects of invasive species than about the positive influence they may have in their new environments (Young 2010). It is studied that people may estimate biodiversity that consists of native species higher in value than introduced biodiversity (Dallimer et al. 2012). On the other hand there are studies that state that nativeness of a species plays only a minor role in people's perception of its desirability; Fischer et al. (2011) tried to clarify how different variables affected people's perceptions of desirability of a certain species and got some surprising results especially in regards to species' nativeness. In their study perceived nativeness (meaning what people thought was native or not) did not affect people's opinions on the desirability of a certain species much. This was an interesting finding because current decision-making policies take nativeness strongly into account (Fischer et al. 2011). Another interesting discovery of the study was that people recognize native and non-native species very poorly. In their study, conducted in Europe and including the total of 2378 samples (completed interviews), one of the study species was a non-native plant. Of the total sample 81% of respondents thought this non-native plant species was native or neutral. As already mentioned, however, even the perception of nativeness was not a big factor in their valuation of the desirability of the species. In contrast, the value and possible harmfulness of a study species had big importance in people's opinions on its desirability. (Fischer et al. 2011)

Ecosystem services are differently used and understood in different parts of the world (Egoh et al. 2012) and the same is probably true for introduced species (Fischer et al. 2011). The previously referred study of Fischer et al. (2011) was conducted wholly in Europe and therefore does not necessarily reflect the mindsets of all seven billion people living on planet Earth. There are big differences in perspective and attitudes even inside Europe, e. g. between Scandinavian and Mediterranean areas (Fischer et al. 2011), so the differences in culture and beliefs between continents are also without a doubt substantial.

5. Study methods

This study was conducted as a semi-structured interview study. The questionnaires of the interviews can be found at the end of this thesis, in Appendix 1a and 1b. Forty-five interviews were conducted in households around Taita Hills and one interview was conducted at a local tree nursery. All household interviews were conducted with an interpreter present (English to Swahili/Taita) while the tree nursery interview was conducted wholly in English. Data obtained from the interviews was then assessed both qualitatively and quantitatively.

5.1 Aims of research

This study was set out to find answers to the following principal research questions:

- Which ecosystem services local people of Taita Hills recognize in their environment?
- What perceptions local people of Taita Hills have of biodiversity?
- Do local people of Taita Hills have any opinions on harmfulness of introduced plant species?

5.2 Study species

The eleven study species used during the household interviews consist of ten plants and one lichen. Study species are (from a-z) *Acacia mearnsii*, *Albizia gummifera*, *Eucalyptus sp.*, *Ficus sur*, *Impatiens teitensis*, *Orthostichella sp.*, *Phoenix reclinata*, *Pteridium aquilinum*, *Ricinus communis*, *Tithonia diversifolia* and *Usnea sp.* They were chosen from different families and origins in order to get a wide-ranging view of local people's relationship with their environment. Some of the study species are indigenous to Taita Hills and some are exotic. Study species also vary greatly in size; the biggest species are up to 65 m tall trees and the smallest are lichens growing on thin branches. Some of the study species are beautiful flowers and some are less imposing mosses. All these factors affect people's perception of the species and the objective was to find out if their perception matches the ideas previously found out in similar studies. Local Taita names for the study species can be found in brackets after the scientific name of the study species.

Acacia mearnsii (mgamu, mvudi, mngamu)

Acacia mearnsii (Black wattle, Fig. 13) is commonly found in Taita Hills. It is an exotic tree species and is native to Australia. It was introduced to Taita Hills in the early 1900s to answer leather factories' needs; *Acacia mearnsii*'s bark can be used to produce shoe polish. Before *Acacia mearnsii* was introduced to Taita Hills the overall tree cover was at a very low point (Pellikka et al. 2009) so its introduction affected tree cover positively. Plantations of *Acacia mearnsii* and other exotic tree species (e. g. *Pinus patula*, *Cupressus lusitanica*) have also been established by the forest department in bare areas to prevent soil erosion (Bytebier 2001). When flowering, small yellow flowers cover the whole tree making it easily recognizable (Fig. 13). Its leaves are feathery and leaflets extremely small (Dharani 2011). It can grow up to 25 m. *Acacia mearnsii* is a nitrogen-fixing plant which means it enriches the soil by making nitrogen bioavailable to other species. (ICRAF 2014b)

Acacia mearnsii thrives at high elevations as well as low ones and can grow on slopes (even up to 50 degree slope) with only shallow layers of soil. This means it can control soil erosion well and is suitable for the conditions of Taita Hills. The species was first introduced to Taita Hills as a source of tannin for shoe industry but it is now a valuable fuel wood to local people as well. Charcoal obtained from *Acacia mearnsii* is widely used as domestic fuel all over Kenya. (ICRAF 2014b)

Figure 13. *Acacia mearnsii* (left) and *Albizia gummifera* (right). Photographs by E. Tuomaala (2013).

Albizia gummifera (msuruwache)

Albizia gummifera (Peacock flower, Fig. 13) has a crown-like canopy and dark green leaves. It is indigenous to Taita Hills and is quite common around the area. *Albizia gummifera* is a big tree growing up to 30 m in height (ICRAF 2014c).

Albizia gummifera is known to control erosion with its voluminous root system. Its wood is also used as firewood and timber, although it is not considered to be very strong wood. In East Africa Albizia gummifera is known to be used as a medicine for stomach pains and malaria. In Kenya, it is known as a good mulch tree that makes the soil fertile. In Ethiopia, *Albizia gummifera* trees can be left standing also in farmland because it is believed to support the growth of farm crops. *Albizia gummifera* also has ceremonial uses e. g. as a meeting tree and its leaves can quicken the process of banana ripening. (ICRAF 2014c)

Eucalyptus sp. (mkongo, mrahani, msandoku)

Eucalyptus saligna (Sydney blue gum, Fig. 14) is one of the most common Eucalyptus trees in Taita Hills. It is an exotic tree species there and native to Australia. It was introduced to Taita Hills between 1950s and 1970s in an attempt to have more plantations for wood production (Pellikka et al. 2009).

Eucalyptus saligna can grow up to 50-65 m in height and its diameter can be as wide as 2.5 m. It is a fast-growing tree that can quickly subdue competing vegetation surrounding the sprout which enables it to spread quickly to areas that are suitable for its growth. *Eucalyptus saligna* can tolerate short dry seasons but flourishes in areas where the rainfall is even throughout the year. The species is commonly used in reforestation because it is fast-growing and grows in different kinds of environments. Its timber is hard and easy to work with which makes *Eucalyptus saligna* a good tree for construction purposes, too. (ICRAF 2014a)

Eucalyptus saligna is used for many purposes. In addition to revegetation and construction, it is often used as firewood or herbal medicine. Eucalyptus oil derived from the leaves is widely used as a cure for coughs and other respiratory difficulties. Honey can be produced from the nectar in its flowers. (PROTA4U 2014a)

Figure 14. *Eucalyptus sp.* (left) and *Ficus sur* (right). Photographs by E. Tuomaala (2013).

Ficus sur (mkuyu)

Ficus sur (Cape fig, Wild fig; Fig. 14) is a deciduous tree and very widespread in Taita Hills. It is indigenous to the area. It has a rounded crown and can grow up to 25m in height. (Dharani 2011) *Ficus sur* produces fruits, figs, which turn from green to red when they are ripe. Figs are edible but they can contain lots of insects.

The wood of *Ficus sur* is used for many purposes, e. g. construction, drums and beehives. It can also be used as firewood. Different parts of the tree are used as traditional medicines for a multitude of ailments. *Ficus sur* is connected to spiritual and magical beliefs in many African countries and because of this it is often protected and respected. (PROTA4U 2014b) In Taita Hills people strongly associate *Ficus sur* with water resources and rainfall.

Impatiens teitensis

Impatiens teitensis (Fig. 15) is a flowering plant that is endemic to Taita Hills. It has dark green leaves and can grow up to about one meter tall. The flower of

Impatiens teitensis is white with small pink markings in the middle. *Impatiens teitensis* does not need much direct sunlight and it usually grows in forests where there is more moisture and shade. There are hundreds of species of *Impatiens* in the world, including *Impatiens pseudovila* that also grows in Taita Hills. Unlike *Impatiens teitensis*, *Impatiens pseudovila* is exotic to Taita Hills and its coloring is purple. They can both be used as ornaments or as a source of nectar for honey production.

Figure 15. *Impatiens teitensis* (left) and *Orthostichella sp.* (right). Photographs by E. Tuomaala (2013).

Orthostichella sp.

Orthostichella sp. (Fig. 15) is an epiphytic moss species that is indigenous to Taita Hills. As it is epiphytic it grows mostly on trees and their branches taking all of its nutrients and water from the air. Epiphytic plants and lichens are the most vulnerable species to air pollution because of this. They do not grow in polluted environments and can therefore be used as indicator species for air pollution. They also have big role in the hydrology of Taita Hills area as they can absorb large amounts of water and then gradually release it to the environment. There are ongoing studies about this at the moment within TAITAWATER project and results should be available in the coming years.

At the moment, known and reported number of mosses in Taita Hills region is 128 (Enroth et al. 2013). The forests of Taita Hills are suitable habitats for mosses and lichens due to the climatic conditions and also the lack of airborne pollution. If the surrounding areas urbanize in the future, mosses and lichens of Taita Hills might suffer and decrease in number.

Phoenix reclinata (kiangachi)

Phoenix reclinata (African wild date palm, Fig. 16) is very easy to spot due to its characteristic big, downturned leaves. It is indigenous to Taita Hills and produces edible fruits. Its leaves can grow up to 2.5-4 m long (Dharani 2011; ICRAF 2014d) and can be used in many ways. *Phoenix reclinata* is classified as a succession species which means it is very fast-growing and can colonize bare and disturbed land quickly (Pellikka et al. 2009). This ability has enabled *Phoenix reclinata* to compete with fast-growing introduced species brought to the area and retain its commonness in the scenery of Taita Hills.

Known and recorded uses of *Phoenix reclinata* vary all the way from edible fruits and local brew to water troughs. *Phoenix reclinata* provides a variety of different ecosystem services and can be considered one of the most important plant species for the local consumption in Taita Hills. It is also the only species in Taita Hills documented to have commercial value. (Bytebier 2001) This commercial value comes mainly from the selling of different products made of *Phoenix reclinata*, such as baskets and mats.

Figure 16. *Phoenix reclinata* (left) and *Pteridium aquilinum* (right). Photographs by E. Tuomaala (2013).

Pteridium aquilinum (lusu, chusu)

Pteridium aquilinum (Bracken fern, Fig. 16) is a cosmopolite species and especially common in temperate zones. It is present on all continents, including Antarctica, making it one of the most widespread plant species in the world. In Africa it ranges all the way from the Mediterranean to the Cape. (PROTA4U 2014c)

Pteridium aquilinum is commonly used as a cooked vegetable, especially in Africa. It is also used as beddings for livestock and its leaves can be used to filter oil. Known medicinal usages also exist; *Pteridium aquilinum* has been reported to be used e. g. to cure infertility and mental disabilities. It can also be used as a pesticide or in soap production. (PROTA4U 2014c)

Ricinus communis (mbonu)

Ricinus communis (Castor-oil plant, Fig. 17) is commonly found around Taita Hills and is indigenous to the area. Its stem is multi-branched and it has characteristic deeply lobed leafs. *Ricinus communis* can survive in a multitude of environments, even in disturbed grounds (Dharani 2011), which has enabled it to spread all around the world. It is widely cultivated in the tropics and sub-tropics and occurs all around the African continent (PROTA4U 2014d).

Ricinus communis is mostly known for its ability to produce castor-oil, with about 95% of the seeds used for extraction of oil. *Ricinus communis* is indigenous to north-eastern tropical Africa. It was grown for its oil already in Egypt some 6000 years ago and spread through the Mediterranean, the Middle East and India at an early date. It is now widely cultivated in the driest areas of the tropics and sub-tropics and in many temperate areas with a hot summer. It naturalizes easily and grows in many areas as a ruderal plant; it is often found as a ruderal near villages and in urban regions while under natural conditions in north-eastern Africa it occurs commonly along seasonally dry rivers. *Ricinus communis* occurs across the African continent, all the way from the Atlantic coast to The Red Sea and from Tunisia to South Africa and in the islands of The Indian Ocean. (PROTA4U 2014d)

Figure 17. *Ricinus communis* (left) and *Tithonia diversifolia* (right). Photographs by E. Tuomaala (2013).

Tithonia diversifolia (mwakiwawira)

Tithonia diversifolia (Mexican sunflower, Fig. 17) is very common around Taita Hills. It is an exotic plant species, native to Mexico and Central America and Zanzibar. It grows along the roads and farms all around Taita Hills being one of the most common study species there. *Tithonia diversifolia* can grow up to 3 m tall, is a fast-growing species and reasonably resistant to aridity. In Kenya, *Tithonia diversifolia* is the most planted ornamental species. (ICRAF 2014e)

Usnea sp.

Indigenous forests with minimal human impact often have rich lichen communities. In Taita Hills *Usnea sp.* (Fig. 18) is one of the lichens that has lots of biomass in untouched forests and that affects water balance of the area together with other lichens and mosses. It thrives especially in the canopy of untouched forests. Water regulation of lichens and mosses extends from the cloud forests to the surrounding lowland areas in the watershed, too. Water tends to be more evenly distributed when large biomass of lichens and mosses helps to regulate its flow. (Toivonen et al. 2012) Some lichens might have been introduced to Taita Hills with the exotic tree species that have been brought to the area. Especially *Acacia mearnsii* has been ascertained to provide suitable habitats for lichens. (Toivonen et al. 2012)

Figure 18. *Usnea sp.* Photographs by E. Tuomaala (2013).

5.3 Data collection - the interviews

Data used in this study was collected from the semi-structured interviews conducted around Taita Hills. Households were randomly selected and one person per household was interviewed (with few exceptions; see 5.3.1). Some of the interviews were conducted indoors and some outdoors but all of them right there on the spot; no interviews were agreed on beforehand.

5.3.1 Household interviews

The forty-five interviews were divided into three smaller study areas situated in Taita Hills (chapter 2.2.1) and fifteen interviews were conducted at each location. The interview was divided into two parts: part one discussed ecosystem services related to the eleven study species and part two handled environment from a wider viewpoint – study species were not involved in the questions of part two. In addition to these two parts background information such as age and gender were collected from each respondent. A local research assistant was present during all forty-five interviews and was needed as an interpreter in most of them as local people did not speak English well enough to understand all the questions. Almost all of the respondents were interviewed individually but in a few interviews there were more than one respondent. Respondents were randomly selected and they represent quite well both genders and a variety of age groups.

In the household interviews the respondents were shown eleven pictures, ten (10) of plants and one (1) of lichen (Appendix 2). The pictures were shown in random order to each respondent. The questions of part one were also posed in random order under each species.

5.3.2 Tree nursery interview

In addition to the forty-five household interviews one interview was conducted at a local tree nursery. This tree nursery sold tree seedlings to the local people and was owned by Kenya Forest Service (KFS). The interview was conducted in English and without an interpreter as opposed to all the household interviews. The respondent was an employee of the tree nursery. The question form of this interview can be found from Appendix 1b. Questions were mostly related to the differences between indigenous and exotic tree seedlings sold at the nursery.

5.4 Qualitative and quantitative assessment

Results were mostly analyzed qualitatively as the interview contained lots of open-ended questions. Data obtained from the interviews was coded and similar answers were collected under the same categories. Portions of the material acquired from the interviews could also be quantitatively assessed. Quantitative assessment could be applied to data that constituted of numbers, e. g. recognition of study species in different study areas (number of study species recognized).

Different methods to analyze the data were used; one-way analysis of variance (one-way ANOVA) was applied to multiple datasets containing results from the three study areas to analyze if the difference between these study areas was statistically significant. The Pearson's R correlation test was used to analyze the data of familiarity and usage of study species to find out any underlying correlations there. It was also used to analyze the correlation between opinions on nativeness of species.

6. Results

The results of this study are roughly divided under three categories: 1) opinions on the eleven study species (e. g. recognition, ecosystem services provided, value, harmfulness), 2) perceptions of biodiversity and 3) general views of ecosystem services in Taita Hills.

6.1 The eleven study species under inspection

Descriptions of the study species can be found in chapter 5.2 and pictures of the study species shown during the interviews can be found in Appendix 2.

6.1.1 Recognition

The respondents recognized all study species relatively well (Fig. 19). The most recognized species, *Phoenix reclinata*, was recognized by all forty-five respondents and the least recognized species, *Usnea sp.*, was known to sixteen respondents, which is more than one third of all respondents. Five species, *Phoenix reclinata*, *Pteridium aquilinum*, *Ricinus communis*, *Eucalyptus sp.* and *Tithonia diversifolia*, were recognized by more than forty respondents.

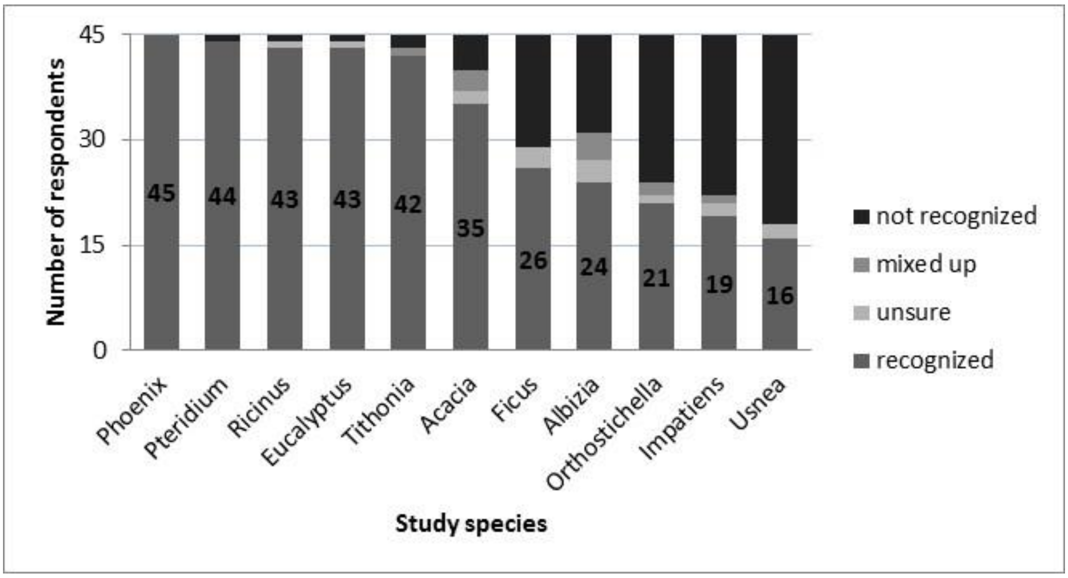

Figure 19. Recognition of the study species in all three study areas combined.

Most respondents recognized nine study species out of the eleven pictures shown to them (Fig. 20). Five respondents recognized all eleven study species and on average the respondents recognized eight study species.

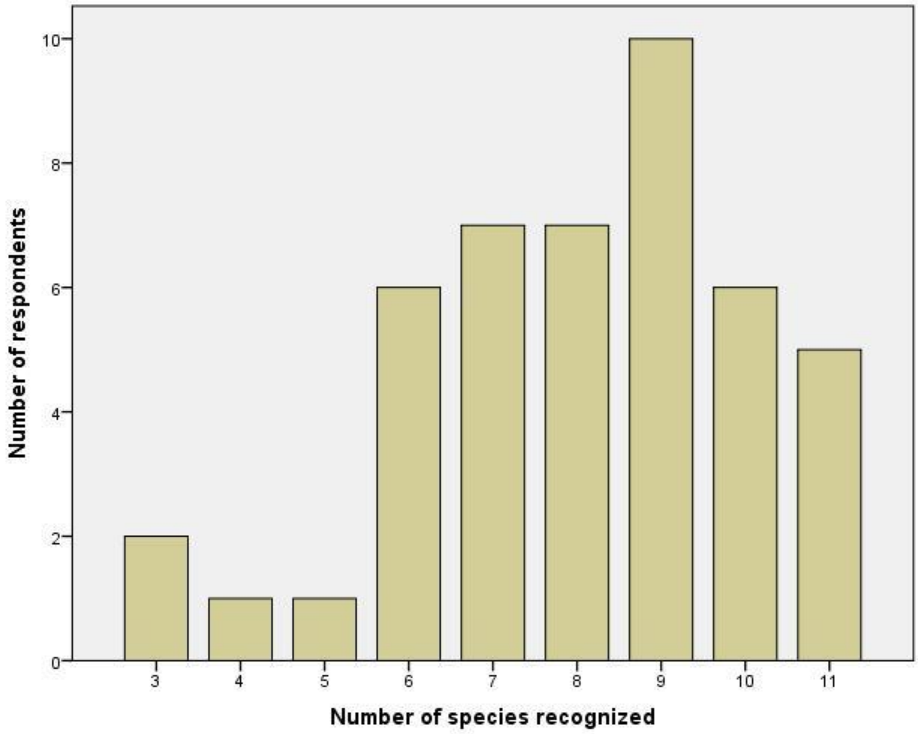

Figure 20. Number of study species recognized. Most respondents (10) recognized nine study species.

There was slight difference in the recognition of study species between the three study areas (Fig. 21). This difference was not statistically significant (overall p = 0.091 > 0.05), however, except for the recognition of study species between Wundanyi and Mwanda study areas ($p = 0.05 \leq 0.05$) where the confidence level of statistical significance was 95 % (Table 5). Overall the respondents in Wundanyi study area recognized the least species while the respondents in Mwanda study area recognized the most species. The dispersion of answers was greatest in Wundanyi study area and smallest in Ngangao study area.

Table 5. Variation in recognition of the study species between all three study areas (upper) and between Wundanyi and Mwanda study areas (lower).

All study areas	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19,911	2	9,956	2,533	,091
Within Groups	165,067	42	3,930		
Total	184,978	44			
Wundanyi & Mwanda	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19,200	1	19,200	4,178	,050
Within Groups	128,667	28	4,595		
Total	147,867	29			

The composition of recognized species also varied between the study areas (Fig. 22). The most recognized species did not vary much between the study areas but there were some clearer differences with the least recognized study species; for instance the variation in recognition of *Orthostichella sp.* between the study areas was statistically significant with a confidence level of 95 % ($p = 0.012$; $0.05 > p > 0.01$).

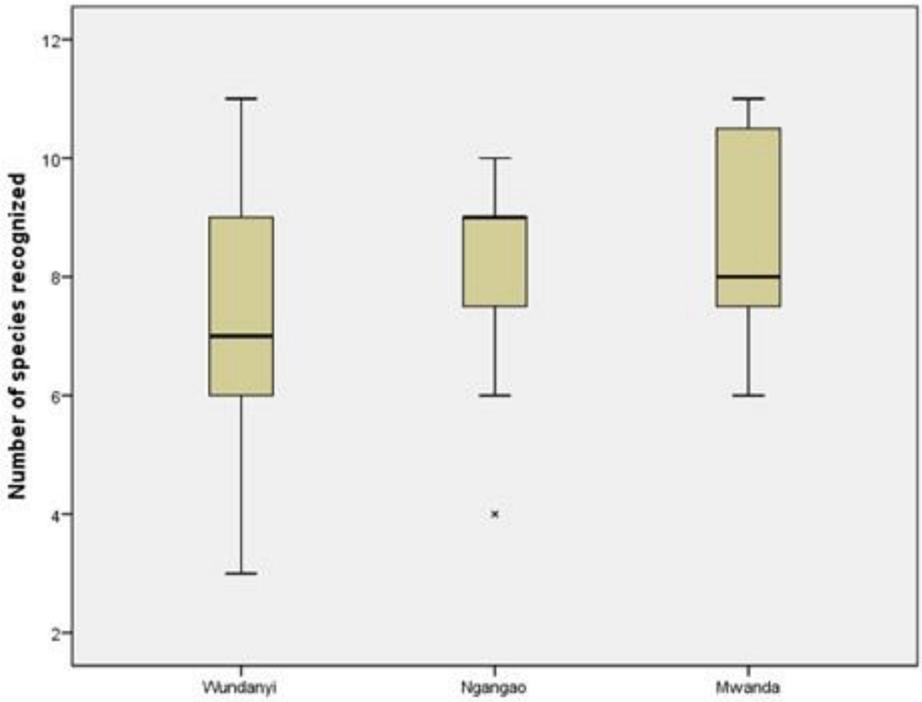

Figure 21. Recognition of the study species in three study areas in a box plot chart. Boxes represent the middle half of data with the bolded horizontal line showing the second quartile value a.k.a. the median number of species recognized in each study area. Whiskers show minimum and maximum values of recognition in each study area expect for the minimum value in Ngangao study area where it is shown as a separate outlier (cross).

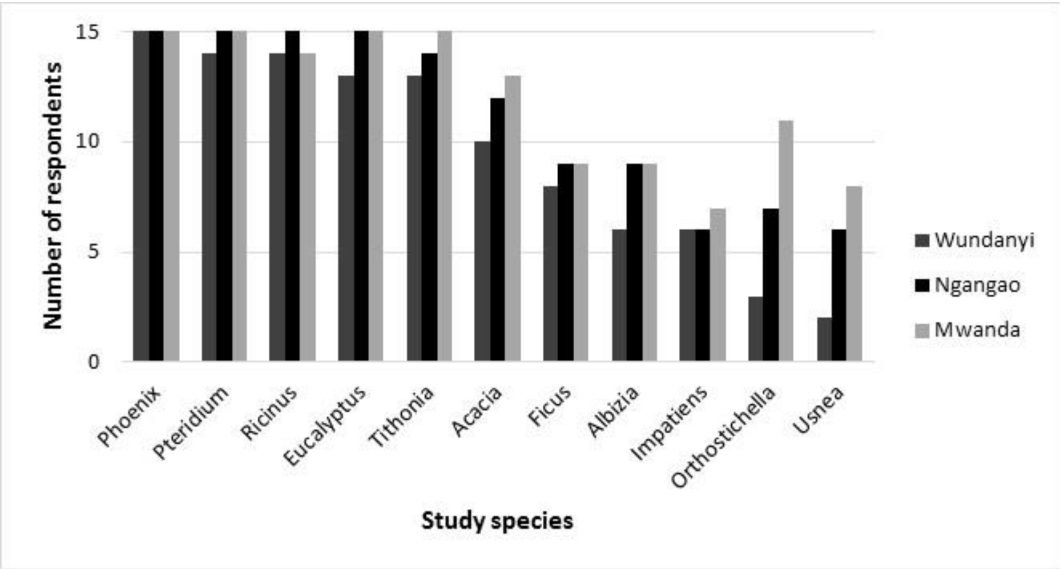

Figure 22. Recognition of the study species in the three study areas.

There was also small difference between genders and age groups but these were not statistically significant and on the whole answers were quite similar with all respondents. Male respondents recognized study species slightly better overall and the variation of their answers was smaller on average (Fig. 23). Male respondents of this study were a little older (45.2 years) than the female respondents (39.1 years).

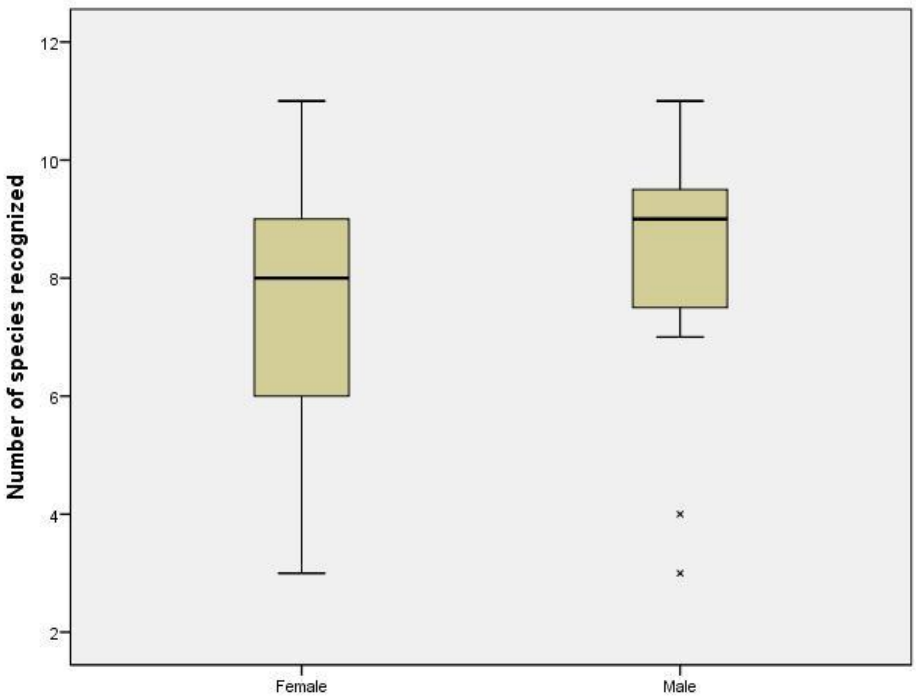

Figure 23. Recognition of study species between genders in a box plot chart. Boxes represent the middle half of data with the bolded horizontal lines indicating the second quartile value a.k.a. the median number of species recognized. Whiskers (and outliers) show the minimum and maximum values of the dataset.

6.1.2 Familiarity

There was variation between the three study areas as to what was considered the most familiar or the most used species. In Wundanyi study area the most familiar species was *Eucalyptus sp.* which also was the most used species there (Fig. 24). In Ngangao study area the most familiar species was *Acacia mearnsii* but there were three species that were evenly named as the most used ones – *Acacia mearnsii*, *Eucalyptus sp.* and *Tithonia diversifolia*. In Mwanda study area the most familiar species was *Acacia mearnsii* (followed closely by *Tithonia diversifolia*) which was also the most used species there. In summary, the most familiar species did not correspond the most used species in Ngangao and Mwanda study areas but they did in Wundanyi study area.

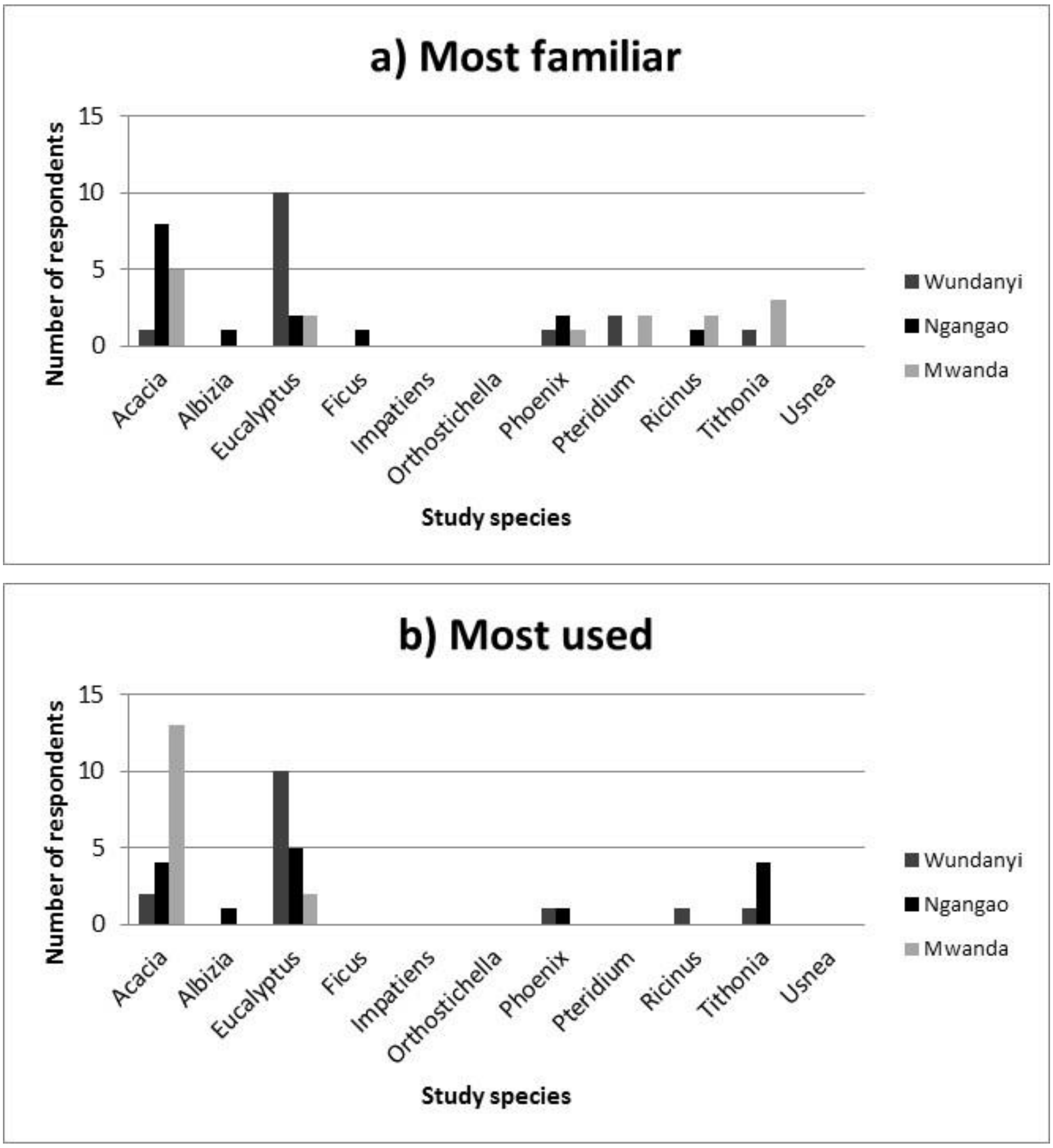

Figure 24. The a) most familiar and the b) most used species in the three study areas.

When the three study areas were compared in a one-way ANOVA test, p-value of familiarity was 0.086 and p-value of usage was 0.004. This means that the most used study species varied statistically significantly with a confidence level of 99 % ($p < 0.01$) between the three study areas and the most familiar study species varied to some extent between the three study areas but this variation was not statistically significant ($p > 0.05$).

There seemed to be clear correlation between the familiarity and usage of the eleven study species when all three study areas were combined. The Pearson product-moment correlation coefficient for this was 0.966 which indicates strong positive correlation (Table 6). When the study areas were examined separately the correlation between familiarity and usage of a given study species was not as strong. In Wundanyi study area this correlation was 0.965, in Ngangao study area 0.535 and in Mwanda study area 0.763.

Table 6. Correlation between familiarity and usage of the eleven study species in all three study areas.

Correlations

		familiarity	usage
familiarity	Pearson Correlation	1	,966**
	Sig. (2-tailed)		,000
	N	11	11
usage	Pearson Correlation	,966**	1
	Sig. (2-tailed)	,000	
	N	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

6.1.3 Value and harmfulness

Respondents were also asked about the monetary value of all eleven study species. They were asked how much each of the study species was worth to them in Kenyan Shillings (Ksh). Some study species were easier for the respondents to valuate than others. Majority of the respondents could come up with a monetary value for the tree species in this study (Fig. 25) as well as for *Ricinus communis* and *Tithonia* *diversifolia*. The monetary values given to the four tree species described the value of one tree. *Eucalyptus sp.* was estimated to be the most valuable of these four tree species in all three study areas. Monetary values given to *Ficus sur* varied the most ranging from 50 Ksh to 10 000 Ksh.

With the fifth tree species of the study, *Phoenix reclinata*, respondents could better valuate different kinds of products made of it. The product made of *Phoenix reclinata* mentioned the most was a basket, and the average monetary value given to it was 270 Ksh.

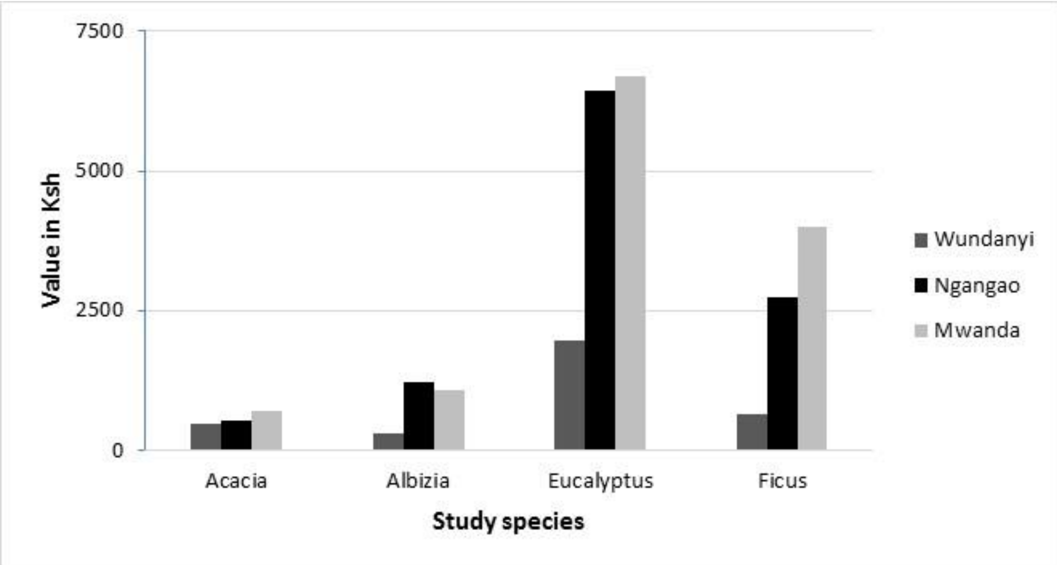

Figure 25. Average monetary values (Ksh) of one tree of these four study species as seen by the respondents in the three study areas.

Some study species were considered to be more harmful than others. The study species regarded as the least harmful was *Ricinus communis*, which got thirty-three "not harmful" answers among the forty-five respondents. *Pteridium aquilinum* was considered to be the most harmful study species with only twelve "not harmful" answers.

Respondents gave many different reasons as to why a certain study species was harmful. Similar answers were repeated by many respondents with certain study species, e. g. *Eucalyptus sp.* was considered to be harmful by twenty respondents because it consumes lots of water and therefore makes rivers and springs dry up. Respondents agreed also on dangerous, prickly thorns of *Phoenix reclinata* being harmful (14 respondents), *Tithonia diversifolia* leaving a bitter smell to one's hands (9 respondents) as well as *Pteridium aquilinum* to be poisonous to cows (15 respondents) and also to cause deep cuts to humans (11 respondents). Many of the study species are used as traditional medicines in Taita Hills (chapter 6.2.4) and respondents reminded that overdosing of any medicine concocted of the study species can be extremely dangerous. Many of the study species were also suspected to compete with farm crops in regards to nutrients and water which made them harmful in farm environment according to some respondents.

6.1.4 Ecosystem services

The respondents recognized a total of fifty-four ecosystem services provided by the eleven study species (Appendix 3). These services were further divided into forty main ecosystem service categories (e. g. category "oil" contains sub-categories castor-oil, hair oil, lotion/oil on skin and lubrication oil). *Phoenix reclinata* was considered to provide the most services with nineteen different services provided, and *Usnea sp.* was considered to provide the least services with only two services provided. The most recognized ecosystem service provided by the study species was medicinal usage; nine species out of eleven were considered to possess some medicinal qualities.

All four ecosystem service categories were represented in the answers concerning the study species, although provisioning services were markedly the most recognized services; more than 80 % of the mentioned ecosystem services were provisioning services in all three study areas (Fig. 26). Supporting services were most prominent in Ngangao study area (8 %) and cultural services were most recognized in Mwanda study area (4 %).

Out of the eleven study species *Phoenix reclinata* could be considered a keystone species for ecosystem service provision with the nineteen different services it provided. *Phoenix reclinata* was reported to provide ecosystem services from all four service categories.

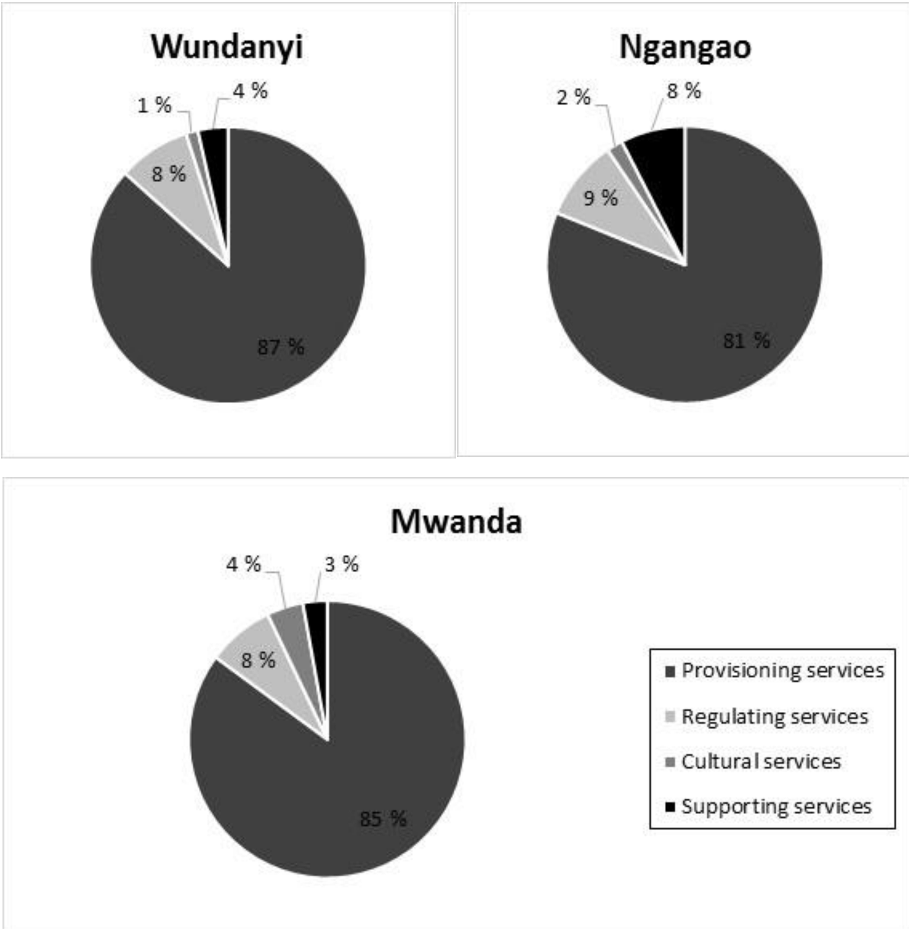

Figure 26. Ecosystem services' division into ecosystem service categories in three study areas.

6.2 Ecosystem services in Taita Hills

When the questions continued on to part two of the interview, respondents named more ecosystem services they recognized from the environment. In these questions there were no restrictions in terms of specific species providing the services. More regulating and cultural services were mentioned in the answers of these questions as well as provisioning services that had already come up during the first part of the interview. Provisioning services mentioned the most were firewood, timber and food. The most familiar regulating services amongst the respondents were rain attraction, air purification and shade provision. Aesthetic values and educational values were the most mentioned in the category of cultural ecosystem services. In part two of the interview some respondents even mentioned tourism and research values that environment could bring to the area.

6.2.1 Water

Few single ecosystem services were picked from the answers and analyzed more closely. Water is the first one of these services partly because this thesis is part of TAITAWATER project that researches the role of water in Taita Hills and partly because water was one of the most important ecosystem services based on the answers of this study as well.

Water can be somehow linked to all four ecosystem service categories. "Fresh water" is a sub-category of provisioning services, "water regulation" is a sub-category of regulating services and "water cycling" is a sub-category of supporting services in MA (2005b). Many recreational cultural services can also be linked to water, e. g. swimming or sailing. Almost all respondents brought up the importance of water and rains at some point of the interview; during the second part of the interview 73 % of respondents mentioned the importance of water. Over half of the respondents (51 %) said that trees and plants have an important role in attracting rains. Different water-related ecosystem services such as water retention and water filtration are therefore very important to the people of Taita Hills.

One of the study species, *Ficus sur*, was strongly linked to the hydrology of Taita Hills based on the answers of the interview. *Ficus sur* was believed to attract rains and protect catchments and the respondents strongly associated it with water. It can therefore be considered to be a keystone species for water related ecosystem services.

6.2.2 Firewood

Firewood provision was also one of the most mentioned ecosystem services in both part one and two of the interview. The concept of ecosystem services keystone species was discussed earlier in chapter 4.2.1. The results of this study show that people recognized more ecosystem services in certain study species than others making these species the keystone species of ecosystem services in this study. In the case of firewood, three study species were highlighted in all three study areas: *Acacia mearnsii*, *Albizia gummifera* and *Eucalyptus sp.* This is presented in Fig. 27 where only the respondents who recognized the study species in the first place were taken into account and the percentages of them naming firewood as an ecosystem service are shown. For instance in Wundanyi study area every respondent who recognized *Acacia mearnsii* thought it provides firewood and in Ngangao study area 92% of the respondents recognizing *Acacia mearnsii* thought it provides firewood. Even in these three closely situated study areas certain differences in habits of using firewood can be pointed out. In Wundanyi, Ngangao and Mwanda study areas the keystone species of firewood production are *Eucalyptus sp.*, *Albizia gummifera* and *Acacia mearnsii*, respectively.

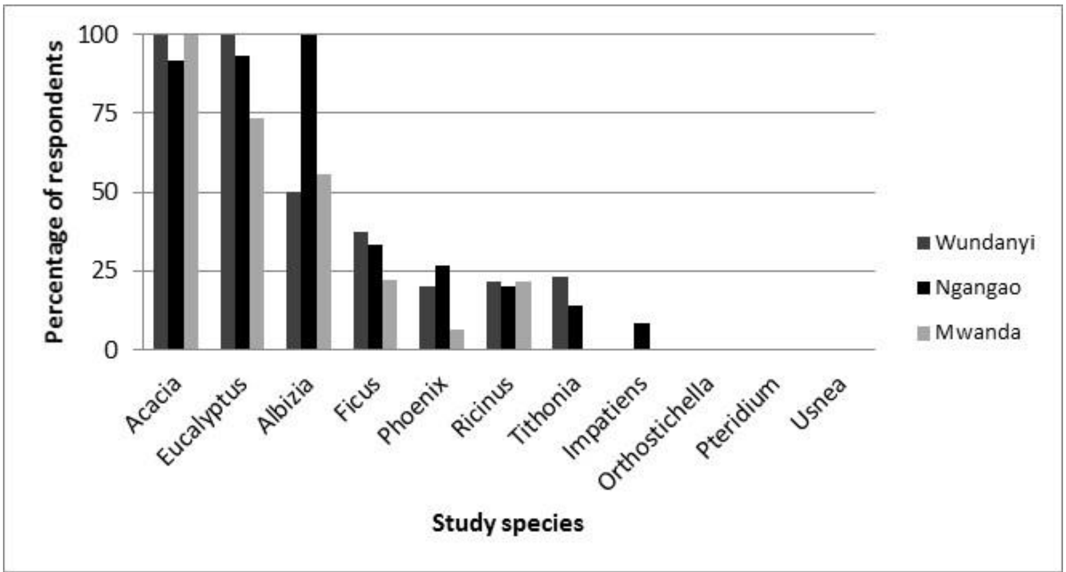

Figure 27. Study species that the respondents considered as firewood.

6.2.3 Aesthetic values and ornamental resources

In part one of the interview four study species were considered as ornaments. Ornamental usage of *Impatiens teitensis*, *Orthostichella sp.*, *Ricinus communis* and *Tithonia diversifolia* was recognized by the total of ten respondents (Wundanyi: 2, Ngangao: 2, Mwanda: 6). “Ornamental resources” is a sub-category of provisioning services and “aesthetic values” is a sub-category of cultural services according to MA (2005b). Ornamental resources are more strongly linked to specific species and products made of them while aesthetic values describe larger environment. This is why ornamental usage of certain study species was counted as a provisioning service in this study.

In part two of the interview the sub-category of “aesthetic values” was more prominent. The questions in this part were not directly related to any specific species and the respondents gave answers concerning the whole environment. Almost half of the respondents, 22 out of 45, mentioned the beautifulness of nature to be important to them and to be a fundamental part of human well-being produced by nature.

6.2.4 Medicinal usage

Medicinal usage of the study species was an important ecosystem service mentioned by the respondents. Nine study species were believed to have some medicinal qualities and in part one of the interview medicinal usage was mentioned by 26 respondents in total. In part two of the interview eight respondents directly mentioned medicinal usage. *Orthostichella sp.* and *Phoenix reclinata* were the only study species that were stated not to possess any medicinal qualities.

Different kinds of ailments and maladies that the nine study species were reported to cure are presented in Table 7. *Tithonia diversifolia* was the most versatile natural medicine as it was reported to cure the total of five different ailments in addition to being a good medicine for animals (e. g. livestock) which makes it a keystone species of ecosystem services linked to medicinal usage. The unknown column in

Table 7 represents answers of the respondents that could not specify which ailment the study species was supposed to cure but knew it cured something. *Impatiens teitensis* and *Usnea sp.* can be found only in this column because none of the respondents could name a specific ailment cured by them even though they were sure they cured something.

Table 7. Ailments and maladies the study species can cure.

	cough	fever	headache	high blood pressure	joint pains	malaria	stomach problems	toothache	wounds	animals	unknown
Acacia mearnsii	x										
Albizia gummifera	x	x								x	
Eucalyptus sp.				x	x		x				x
Ficus sur	x							x			
Impatiens teitensis											x
Pteridium aquilinum									x		x
Ricinus communis			x				x				x
Tithonia diversifolia	x	x				x	x	x		x	x
Usnea sp.											x

6.3 Perceptions of biodiversity

Almost all respondents (43 out of 45) preferred an environment with lots of different plant species as opposed to an environment with just a few different plant species. In Ngangao study area all fifteen respondents preferred a diverse environment and in both Wundanyi and Mwanda study areas there was only one respondent, respectively, who preferred an environment with just a few different species.

When asked what the diversity of nature meant to people the answers were very diverse. Most people connected diversity of nature with water and rainfall as well as well-being and health. Some connected it to concrete benefits derived from nature, others had a more spiritual way of seeing it. Variety of uses also came up with the answers concerning diversity of nature. It was important to people that nature provided lots of different benefits for them, both material and immaterial. Respondents often associated plants with forests and forests with biodiversity. They also connected diversity of nature to the unmanaged and untouched nature, such as forests.

Respondents mostly saw the aspects of biodiversity that were beneficial to themselves. In other words respondents saw the ecosystem services provided by biodiversity. Based on the answers of the interview people of Taita Hills saw biodiversity both as a source and a prerequisite for many ecosystem services and as an ecosystem service itself. Respondents felt that biodiversity enhances environment by bringing more rains which in turn help them cultivate their farms and produce food crops. They also thought that when there are more different trees around they can find appropriate firewood easily and have more choices overall. On the other hand many respondents felt that biodiversity made environment look more beautiful. Special emphasis was given to the role of water in people's perceptions of ecosystem services and biodiversity. Many respondents linked water to biodiversity by describing the importance of rivers and catchment areas in regards to farming and also sceneries.

One question in part two of the interview was "What does diversity of nature mean to you?" Answers for this question were diverse; some respondents approached it by describing different benefits diversity provides, some concentrated on the biological aspects of it and some explored its spiritual meaning to them. Below is a rough division of answers into four categories. Many answers could have been placed under multiple categories as respondents often described diversity of nature verbosely but this rough categorization was made so that different ecosystem services provided by the diversity of nature could be more easily recognized.

Category 1: *"Good, clean life"*

Many respondents associated diversity of nature with clean, fresh environment and healthy life overall. Diversity of nature meant a clean environment, strongly linked to fresh water and air, which contributed to a good life according to the respondents of this category. There are lots of ecosystem services that can be linked to this viewpoint. Regulating services such as air purification, water filtration, water retention and climate regulation contribute to this kind of environment, and provisioning services such as clean water and fresh air are the final benefits enjoyed by people.

Category 2: *"Benefits to people"*

The respondents of this category saw diversity of nature as a source of unending benefits to people. They felt that diversity of nature provides a multitude of choices for them in the form of food, firewood, economic income and protection against the varying dangers of life. As ecosystem services are indeed benefits people obtain from nature it is easy to link almost any ecosystem service to this category of answers. However, the respondents directly described mostly provisioning services such as firewood, food or construction materials.

Category 3: *"Biological and ecological importance"*

Many respondents understood diversity of nature as a collection of ecological or biological processes. They explained the relationships between humans, animals and plants and described how they depend on each other in order to survive. They thought that diversity of nature is necessary for the environment to "succeed" and in fact described biodiversity much like in a biology textbook. Many ecosystem services can be associated with this viewpoint, too. Regulating services such as pollination and pest control are strongly linked to the idea of animals depending on each other and affecting each other's lives. Some supporting services could also be linked to this perspective; e. g. photosynthesis is a fundamental process of nature that every living creature depends on.

Category 4: *"Godly, part of our existence"*

The last category of answers included a more abstract and spiritual view of the diversity of nature. Respondents of this category felt that diversity of nature is part of everyone's existence in spiritual level and that all living organisms have importance. Some respondents also associated diversity of nature with God and untouched environment with minimal human interference. From this viewpoint diversity of nature provides mostly cultural services such as existence values or spiritual well-being.

These four categories can be seen in Table 8. Respondents were divided quite evenly between the four categories and it also needs to be remembered that many respondents did not fit in just one category; one that was the strongest based on their answer was chosen for them. Concrete benefits and spiritual values offered by biodiversity were the most recognized aspects of biodiversity among the respondents, however.

Table 8. Different definitions of diversity of nature.

Definition of biodiversity	Number of respondents	Quotes of the answers	Sub-categories of MA (2005b) linked to definition (single ecosystem services in parentheses)
Good and clean life	8	"improves health" "life, clean water, fresh air" "air gets purified"	• RS: air quality regulation (air purification) • RS: water regulation (water retention, water filtration) • RS: climate regulation
Benefits to people	13	"trees can be used in construction" "products from forest can be sold for money" "land gives food when cultivated"	• PS: fuel (firewood) • PS: food (fruits) • PS: fiber (construction materials, baskets)
Ecological/ biological	11	"birds depending on trees for fruits" "bees getting nectar" "natural habitat for birds, wild animals, insects"	• RS: pollination • RS: pest regulation • SS: photosynthesis
Spiritual	13	"untouched environment" "minimal human interference" "living creatures together in the forest" "the way land is" "part of our existence" "whatever surrounds you"	• CS: cultural heritage values (sacred places) • CS: spiritual and religious values • educational values • CS: aesthetic values (scenery)

6.3.1 Negative aspects of biodiversity

The respondents connected harmfulness of biodiversity almost always to human suffering, much like ecosystem services but conversely (disservices). The majority of respondents did not think that diversity of nature could cause any harm, though. In Wundanyi, Ngangao and Mwanda study areas eleven, nine and thirteen respondents out of fifteen, respectively, thought that diversity of nature is solely a positive thing (Fig. 28).

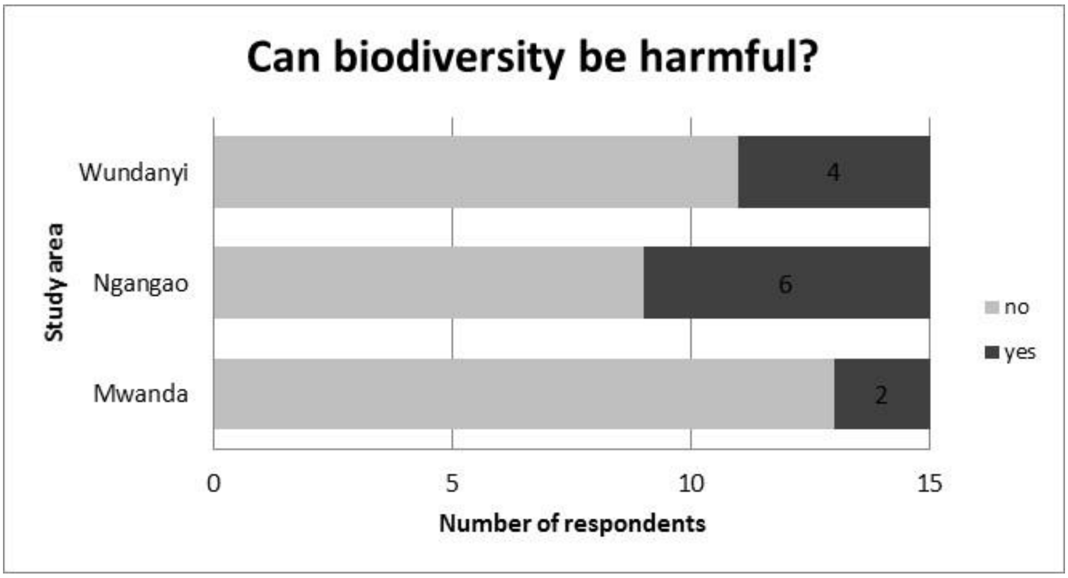

Figure 28. Opinions on harmfulness of biodiversity in the three study areas.

The minority of respondents who thought that diversity of nature can be harmful named mostly harmful things to humans when they were asked to explain their answer. The most used arguments about harmfulness of biodiversity were linked to agriculture and dangerous animals; 70% of all respondents who thought biodiversity could be harmful named these two as the most harmful things biodiversity can cause (Fig. 29). Respondents were worried that biodiversity can affect their crop yield negatively by increasing the number of animals that destroy and eat crops (e. g. monkeys) and that crop plants need to compete with other plants for nutrients in a diverse environment. Many respondents were also scared of dangerous animals such as snakes and bees that could hurt or kill people. There were mentions about flowers causing cough and flu to people, too many rain attracting trees causing floods, trees like *Eucalyptus sp.* causing drought and concern that animals can hurt each other when there are too many of them in the same environment among the answers, too.

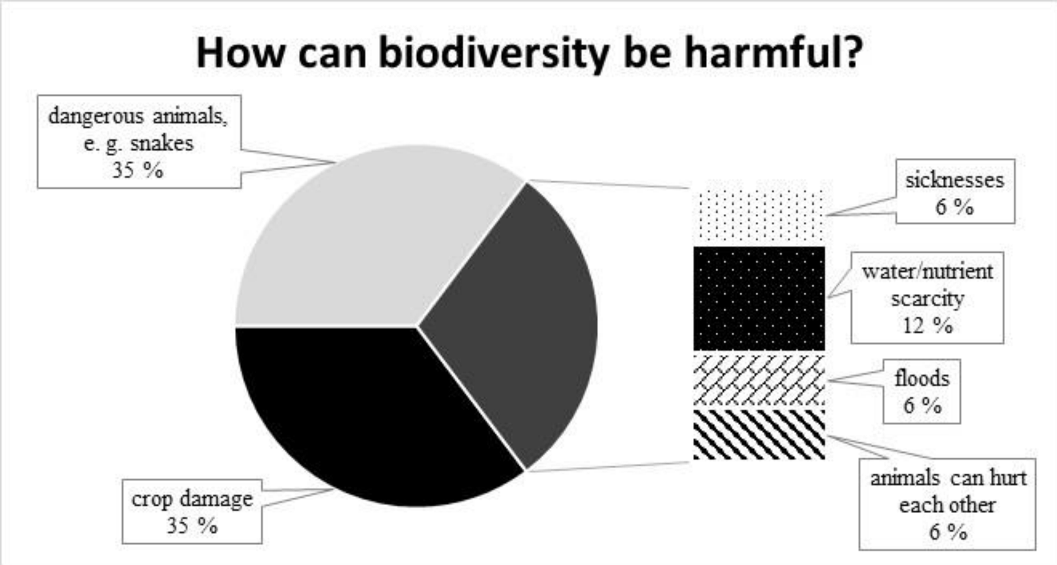

Figure 29. The respondents had different reasons why biodiversity could be harmful.

6.4 Introduced species

The interview at a local tree nursery revealed that people buy mostly exotic tree seedlings from the tree nurseries in Taita Hills. According to the employee of the tree nursery interviewed, about 95 % of seedlings bought are exotic and only 5 % are indigenous. Exotic tree seedlings were cheaper than indigenous ones and they cost only 15 Ksh per exotic seedling compared to 20 Ksh per indigenous seedling.

The most popular species bought from the tree nursery was *Grevillea robusta*, an exotic tree species used mostly as firewood and construction material. The most popular indigenous tree species bought from the tree nursery was *Prunus africana*. Neither of these tree species belonged to the study species of this thesis. According to the employee of the tree nursery people who bought seedlings from them already knew if the seedlings were indigenous or exotic so there was rarely a need to explain the difference to customers.

The vast majority of respondents of the household interviews thought that it would be good for the environment to bring new, strange plant species to Taita Hills. All respondents in Ngangao and Mwanda study areas considered it a positive thing to the environment and only two respondents in Wundanyi study area were against it. In Wundanyi study area most people also thought that there were more exotic than indigenous plant species in Taita Hills as opposed to both Ngangao and Mwanda study areas where people estimated that there are more indigenous than exotic plant species in Taita Hills (Fig. 30).

These two opinions were compared with each other using Pearson's R correlation test. The correlation between answers of "more exotic species" and "bad for environment" was 1.000 when all three study areas were taken into account (N = 3). This indicates full correlation meaning that if this study area level correlation is generalized to affect individuals, people who think there are more exotic than indigenous plant species in Taita Hills often also consider new species harmful to the environment.

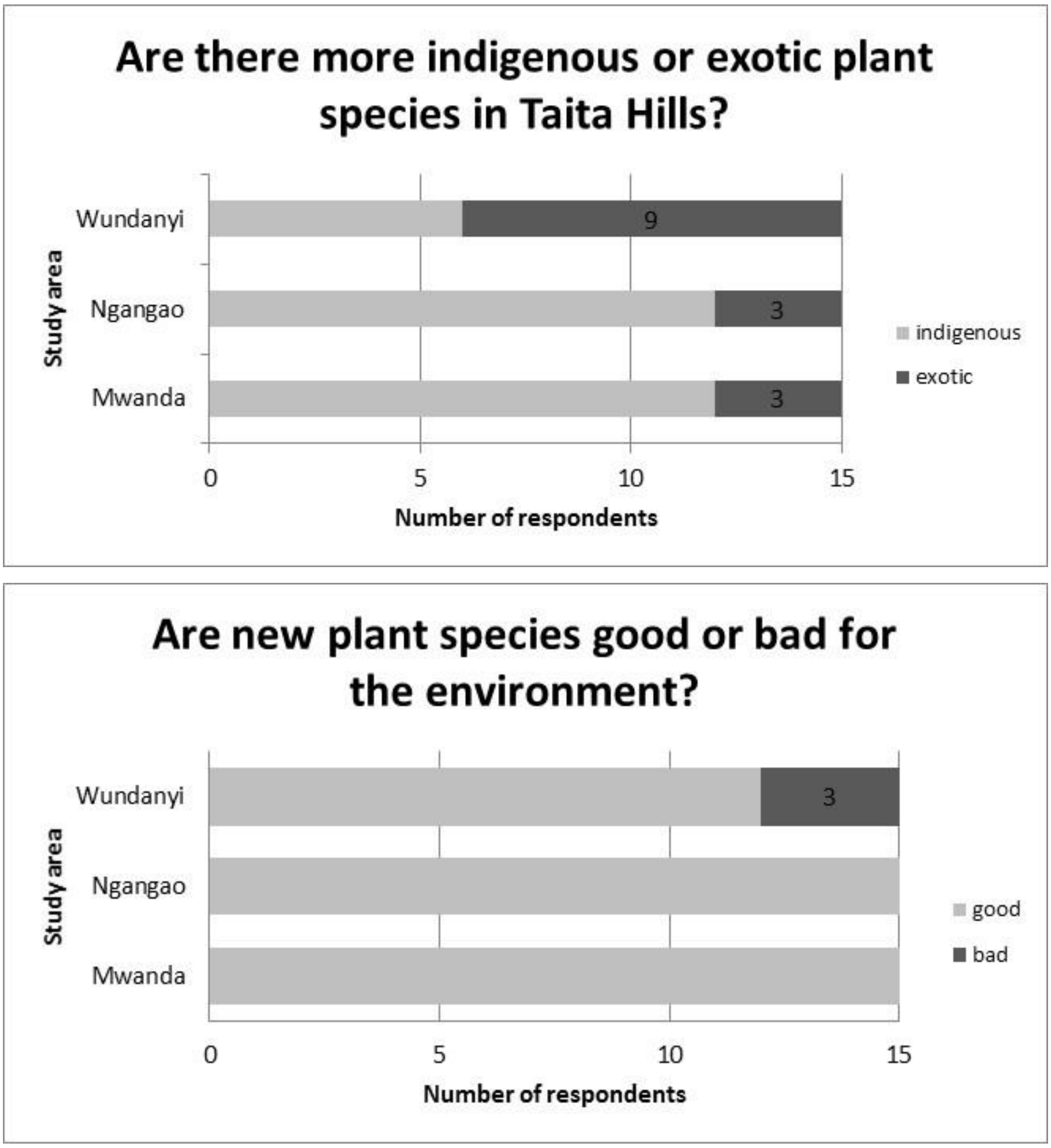

Figure 30. Respodents opinions on indigenous and exotic plant species in Taita Hills.

7. Discussion

The results of the respondents' perceptions of ecosystem services and biodiversity corresponded quite well with the original hypotheses set for the study. Provisioning services were the most recognized ecosystem services amongst the respondents and biodiversity was strongly linked with plants. Previous studies have had similar results of these subjects (Egoh et al. 2012; Lindemann-Matthies et al. 2010).

7.1 Recognition of the study species

Respondents recognized all study species relatively well. Surely, most of the species chosen for this study were quite common in the area and therefore easy to recognize but many the rarer species (e. g. *Orthostichella sp.*) were also recognized well. Recognition of study species seemed to be strongly linked to the usage of them – people recognized best the species they used the most themselves. *Phoenix reclinata* that was the most recognized study species was also the provider of the most ecosystem services. Its versatile usage possibilities made *Phoenix reclinata* familiar to people from different age groups and origins. Ecosystem services' linkage to the recognition of study species was visible with the least recognized species as well; *Usnea sp.* and *Orthostichella sp.* did not provide many ecosystem services according to the respondents.

The most mentioned usage type of the study species was the usage of firewood. This was partly result of the fact that three of the study species, *Acacia mearnsii*, *Albizia gummifera* and *Eucalyptus sp.*, were widely used as firewood in Taita Hills and as there were only eleven study species they covered almost one third of them. The commonness and size of the study species probably also affected their recognition which made big-sized trees easier to recognize than small-sized mosses or lichens.

7.1.1 Most and least recognized species

Some of the chosen study species were very common in Taita Hills and some were not. Some grew only in certain places and some grew practically everywhere. This probably affected the recognition of the study species. Certain species were chosen to the study partly because they only grew in specific places. For instance *Impatiens teitensis* only grows in forests which makes it a good indicator species of forest visiting. *Usnea sp.* and *Orthostichella sp.* also grow mostly in forests as they grow on top of trees. If these three species are examined closer interesting differences between the three study areas can be pointed out. *Impatiens teitensis* was recognized quite similarly in all three study areas but the recognition of *Orthostichella sp.* and *Usnea sp.* brought up some deviation (Fig. 31). Out of these three forest-growing study species the variation in recognition of *Orthostichella sp.* between the three study areas was statistically significant (p = 0.012). With *Usnea sp.* the p-value was 0.067. These values indicate that people recognize forest-growing species better if they live right next to forests as in both Ngangao and Mwanda study areas forest was situated much closer than in the "urban" Wundanyi study area. In the background information part of the interview respondents of Ngangao study area actually reported to visit forests most often. Interestingly, the respondents of Mwanda study area recognized *Orthostichella sp.* and *Usnea sp.* better than the respondents of Ngangao study area even though they reported to visit forests more infrequently. This may tell something about the composition and ecology of nearby forests, too.

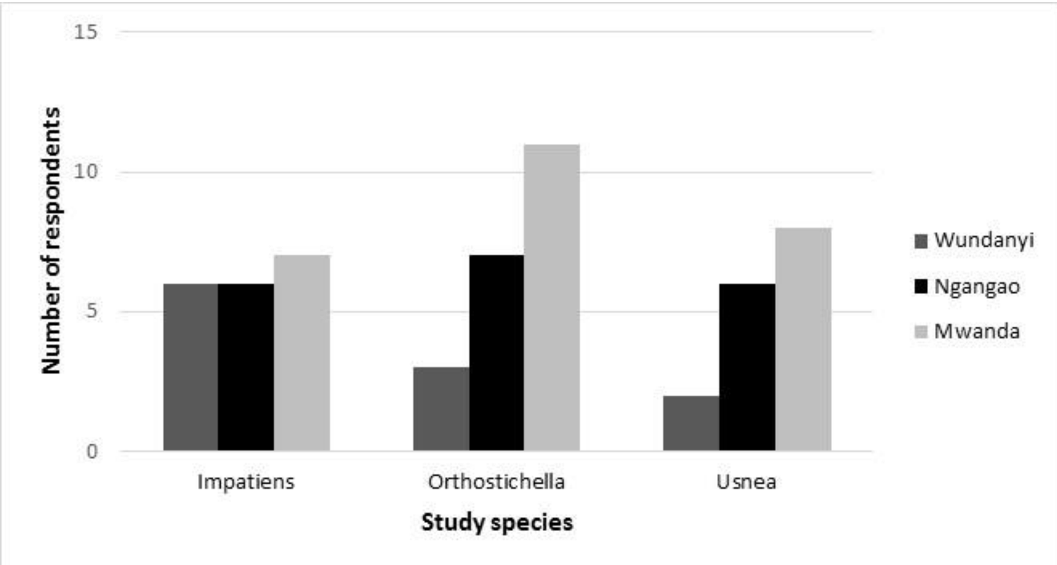

Figure 31. Recognition of *Impatiens teitensis*, *Orthostichella sp.* and *Usnea sp.*, the three forest-growing study species in Wundanyi, Ngangao and Mwanda study areas.

In Ngangao study area the forest that is situated close-by is government owned while in Mwanda study area the forests close-by are community managed. This distinction between the study areas might be the reason explaining why the respondents of Mwanda study area recognized the forest-growing study species even better than those of Ngangao study area; visiting and using community managed forests is less restricted and regulated than government owned forests (Himberg 2011). It was stated in Table 1 that respondents of Ngangao study area visited forests the most often, however. Respondents in Ngangao study area visited forest 7.84 per month in average while the corresponding numbers in Wundanyi and Mwanda study areas were 2.33 and 3.56, respectively. The respondents of Mwanda study area recognized study species the best even when they visited forests less frequently than the respondents of Ngangao study area. This could indicate that community managed forests might accommodate a wider assortment of species than government owned forests and therefore be more beneficial to biodiversity. In Wundanyi study area the respondents visited forest the least which could explain why the respondents there also recognized the least forest-growing study species.

The most recognized study species were *Phoenix reclinata*, *Pteridium aquilinum*, *Ricinus communis*, *Eucalyptus sp.* and *Tithonia diversifolia*. They are all very common plant species in Taita Hills and they can grow in diverse conditions. This makes them familiar to people living in Taita Hills as they can see the plants practically everywhere they go. These plants also have a variety of possible uses that make them well-known to the people of Taita Hills. Two of these five species, *Phoenix reclinata* and *Eucalyptus sp.*, are big-sized trees. *Ricinus communis*, *Pteridium aquilinum* and *Tithonia diversifolia* are all sizeable as well. Bigger species are easier to notice than small species even if they are not used by the person which probably also contributed to the recognition of these five species. In contrast, the three least recognized species, *Impatiens teitensis*, *Orthostichella sp.* and *Usnea sp.*, are small-sized and therefore difficult to notice from the environment if one does not specifically try to find them.

Many respondents tended to mix up *Acacia mearnsii* and *Albizia gummifera* with other plants. This lowered the recognition of both species even though they both are big-sized trees. However, they were also less used than the most recognized species such as *Acacia mearnsii* and *Eucalyptus sp.* (Fig. 24). This indicates that people recognize the species they use themselves better than the species they use only infrequently or never.

The most familiar and the most used study species varied between the three study areas. This was somewhat unexpected as the study areas were situated close-by and the differences between the areas were assumed to not be that significant. The graphs show, however, that clear differences can be perceived to exist between the three study areas (Fig. 24). The variation in usage of the study species varied statistically significantly with a confidence level of 99 %. One of the most distinct observations is that in Mwanda study area the respondents had many different familiar species but one species, *Acacia mearnsii*, rose above all when it came to the usage of the species. In Ngangao study area the situation was somewhat opposite as *Acacia mearnsii* was clearly the most familiar species but the usage of the species was more divided between all species. In Wundanyi study area *Eucalyptus sp.* was quite prominent species as it was both the most familiar and the most used species there.

7.1.2 Desirability of a species; the value and harmfulness of study species

Perceived value, specifically economic value, has been proven to be a good indicator for desirability of a certain species (Fischer et al. 2011). Out of the four tree species mentioned and valuated earlier (chapter 6.1.3) *Eucalyptus sp.* was assessed to be the most valuable in monetary terms. The size of the tree matters here as the respondents gave values to one tree and different species can grow up to different sizes. Despite of this it would seem that *Eucalyptus sp.* was the most valuable tree species to the respondents and would therefore be the most desirable out of these four based on the valuation of them. *Eucalyptus sp.* was in fact widely used especially in Wundanyi study area (Fig. 24) which further promotes its importance in Taita Hills. *Eucalyptus sp.* was also one of the most versatile study species in regards to ecosystem service production with its ten different ecosystem services provided. *Ficus sur* was also estimated to be a valuable tree in monetary terms even though it was not widely used as firewood or building material in the three study areas (Fig. 27) and some respondents even mentioned it was illegal to chop it down or sell it. Its value might therefore be more connected to its role as a spiritual and religious tree linked to the hydrology of the area by the local people (Chapter 6.2.2).

Another important factor in deciding the desirability of a species is its harmfulness. If a species is perceived harmful in some way, it correlates strongly but negatively with its desirability. (Fischer et al. 2011) In this study the respondents were asked if they considered the study species to be harmful. According to them the least harmful study species was *Ricinus communis* and the most harmful study species was *Pteridium aquilinum*. *Eucalyptus sp.* was considered to be harmful by 20 respondents. It would be interesting to find out how and if these factors rule each other out in the case of *Eucalyptus sp.*, because it was considered to be valuable in monetary terms but also harmful by many respondents. Desirability of the species can be found somewhere in between, and obviously there are lots of other factors that complicate the matter even further (e. g. nativeness). Even so, it could be said that people of Taita Hills probably tolerate the negative effects of *Eucalyptus sp.* better because it is also worth a lot to them – and the other way around, local people take the harmfulness of *Eucalyptus sp.* into consideration when they think of its basic monetary value.

Study species of this study were considered to be harmful in a number of ways. Almost all of the harmful effects mentioned were directly linked to humans and therefore represent sort of negative ecosystem services (reduce human well-being; disservices). Popular reasons for a species to be harmful were e. g. toxicity, sharpness of plant parts or unpleasant smell. Indirect effects on human well-being were also mentioned: many species were thought to compete with farm crops in regards to nutrients and water and therefore reduce harvests, some species were reported to kill livestock which caused people to suffer from hunger, and *Usnea sp.* was believed to be a parasite to trees and consequently reduce timber yields. Some more ecological harmful aspects were also mentioned, e. g. *Eucalyptus sp.* was believed to affect the hydrology of the area negatively by draining water from rivers and drying up springs. Nevertheless, most of the harmful aspects named were inconveniences to people. When planning nature conservation areas these perceptions should be taken into account because harmfulness of a species has been discovered to affect its desirability negatively (Fischer et al. 2011) and long-term conservation plans can only be successful if they are accepted by the locals (Sommerville et al. 2010).

7.2 Ecosystem services

The respondents recognized multiple ecosystem services both in the study species shown to them as pictures and in their environment and everyday life. Within the eleven study species the most common ecosystem services recognized were usage as firewood (most mentions) and medicinal usage (widest range of study species).

Respondents named mostly provisioning services when answering questions about the study species (part one of the interview). When the questions went on to discuss biodiversity and introduced species (part two of the interview) the respondents named ecosystem services from a wider range of categories. The main reason for this probably was that regulating and especially cultural services are not as connected to one single species as provisioning services (e. g. tourism vs. firewood). Some regulating and cultural services may not even be possible to be produced by just one species, e. g. scenery is made of a variety of attractive elements in the environment and is almost always comprised of more than one species. This result complies well with the study by Schneiders et al. (2012) where it was stated that biodiversity is more needed for regulating and cultural services than it is for provisioning services.

Aesthetic values belong to the more abstract side of ecosystem services. Beautifulness of nature is a cultural service that produces human well-being in varying degrees around the world. Aesthetic values are very subjective and it is difficult to give any specific monetary values to them but they were well represented in the answers. Many respondents felt that beautiful sceneries are one of the most important aspects of biodiversity and some also connected beautifulness with untouched nature. Aesthetic values were connected to the study species as well because four of them were reported to be used as ornaments (*Impatiens teitensis*, *Orthostichella sp.*, *Ricinus communis* and *Tithonia diversifolia*). People often link biodiversity with plants and some studies suggest that this is because of their attractiveness (Lindemann-Matthies et al. 2010). This attractiveness was well recognized by the respondents of this study as well which supports the theory that appearances do matter in biodiversity conservation to some degree.

The respondents recognized mostly provisioning services provided by the eleven study species. In all three study areas over 80% of ecosystem services recognized were provisioning services (Fig. 26). This correlates well with the statement made by Egoh et al. (2012) that provisioning services are well represented in developing countries where people greatly depend on their environments to survive. Some respondents mentioned abstract ecosystem services such as ecotourism and research values they saw in their environment but majority of the respondents ignored these ecosystem services and concentrated on the concrete benefits nature offers. Overall cultural services were the least mentioned category of ecosystem services. This might be because regulating and supporting services are more present in agricultural environment than cultural services and therefore become more familiar to the local people.

There was slight variation between the three study areas as to which ecosystem service categories were the most prominent. In Ngangao study area supporting services were better recognized than in Wundanyi and Mwanda study areas and their overall percentage was the biggest there; 8% of ecosystem services recognized in Ngangao study area were supporting services (Wundanyi study area: 4%, Mwanda study area: 3%). In Mwanda study area cultural services were most recognized and they represented 4% of all ecosystem services recognized there (Wundanyi: 1%, Ngangao: 2%). In Mwanda study area most of these cultural services were linked to catholic religion, e. g. usage of the leaves of *Phoenix reclinata* during Palm Sundays. Cultural differences can be very regional as this result shows.

Provisioning services were the most dominating in Wundanyi study area where 87% of all ecosystem services recognized were provisioning services. In Ngangao study area this percentage was the lowest, 81%, which might be partly explained by the fact that respondents there had the biggest farms (1.08 ha compared to 0.25 ha of Wundanyi and 0.46 ha of Mwanda) and agriculture was a more prominent livelihood there than in the two other study areas. This made them recognize important supporting services for agriculture such as soil formation and manure use which lowered the percentage of provisioning services recognized. Regulating services represented 8-9% of all ecosystem services recognized in all three study areas.

7.2.1 Keystone species of ecosystem services and biodiversity conservation

Certain species are more important for a given ecosystem than others (Ridder 2008). Out of the eleven study species *Phoenix reclinata* could be considered a keystone species for ecosystem service provision with the nineteen different services it provided (Appendix 3). *Phoenix reclinata* produced ecosystem services from all four service categories. Without *Phoenix reclinata* the ecosystem service provision of Taita Hills would be very different and the lifestyles of local people would have to change drastically. The variety of possible uses of *Phoenix reclinata* promotes its role as a keystone species for ecosystem service production in Taita Hills.

Other keystone species of ecosystem services recognized in this study were *Tithonia diversifolia* and *Ficus sur*. *Tithonia diversifolia* provided only ten different ecosystem services but its role in providing different medicinal services was dominant among the study species. *Tithonia diversifolia* was reported to cure five different ailments and maladies and in addition it was by far the most used natural medicine for animals, especially livestock. Some respondents also mentioned it to cure ailments unknown to them. Medical resources provided by ecosystems is one aspect of the linkage between biodiversity and human health. It is an ecosystem service that gets endangered with biodiversity loss. Other ecosystem services linked directly to human health and enabled by a diverse environment are basic human needs like water, food and clean air, biological control of diseases and contributions to mental health through e. g. recreation (Huynen et al. 2004). Biodiversity conservation is important to preserve medical resources found from the nature. Respondents of this study recognized these medical resources well and their knowledge could be used also in planning conservation areas for medicinal plants.

Ficus sur turned out to be a keystone species for water related ecosystem services. *Ficus sur* was believed to attract rains and protect rivers and catchment areas by many respondents in all three study areas and it was strongly connected to fresh water provision. It was stated to provide ten different ecosystem services but its role in water related services was emphasized among the respondents. Spiritual ecosystem services seemed to be attached to it as well. Other *Ficus* species, e. g. *Ficus sycomorus*, have been discovered to behold spiritual meaning to the local people in previous studies (Himberg. 2011). The same connection to nature was found to exist with *Ficus sur* as well. This might be one of the reasons why *Ficus sur* was not a popular firewood species amongst the respondents of this thesis.

According to Fischer et al. (2011) perceived value and possible harmfulness of a species is a big factor in people's opinion of the desirability of the species. Species that are considered valuable and harmless by local people could therefore act as keystone species for biodiversity conservation. If the conservation plans were to be planned from the viewpoint of these "popular" species the whole conservation effort might be more successful because local people would see their own values in the decisions made. Based on the results of this study *Ficus sur* could be a suitable species for such purposes. It was valuable to the respondents both in monetary terms and as a source of ecosystem services and it was considered to be quite harmless. The only harm a few respondents recognized in it was the fact that its fruits can sometimes contain nasty insects. It could therefore be a good flagship species for biodiversity conservation in the area as it evokes positive feelings in the local people.

7.2.2 Concept of ecosystem services

The concept and definition of ecosystem services by MA (2005c) seems to be quite successful as all respondents of this study quickly understood what was asked of them in regards to different ecosystem services produced by the study species. Most of the respondents did not speak English and the concept had to be explained to them through translation. Even with this intermediary step the respondents comprehended the concept and the idea of the questions quickly. A concept that can easily be explained to a diverse group of people even when they do not have any background information of the concept makes it a good subject of social research. The concept of ecosystem services was such concept.

7.3 Importance of water

The importance of water in Taita Hills has been extensively studied within the TAITAWATER project. This importance could be spotted from this study as well. Previous studies concerning water resources of Taita Hills have discussed e. g. the hydrology of the mountains, water usage in agriculture and the relationship between water and vegetation in Taita Hills. In this study the goal was to find out how regular people of Taita Hills understand their environment and its different aspects, one of them being water.

Water was considered to be a crucial part of people's lives in Taita Hills according to the interviews performed in this study. The respondents linked water and hydrological systems of the area to a multitude of ecosystem services and also considered water to be an important part of biodiversity itself. Many respondents were aware of the problems in water resources caused by *Eucalyptus sp.*, one of the study species of this study. *Eucalyptus sp.* was said to drain rivers and springs by consuming large amounts of water. Some species were linked to water resources positively, too: *Ficus sur* was believed to protect catchments and attract rainfall and therefore keep the environment wet and fruitful.

Another study species, *Usnea sp.*, was not directly associated with water by the respondents of this study but it has been studied a lot in Taita Hills concerning the hydrology of the area in TAITAWATER project. Based on the preliminary results of these studies *Usnea sp.* (along with other lichens) is an important species in water retention and distribution in Taita Hills (Toivonen et al. 2012). It has an ability to absorb large amounts of water and then release it gradually to the environment. While most of the respondents did not have any opinion on the harmfulness of *Usnea sp.*, a few respondents considered it to be a parasite to trees and therefore affect the environment negatively.

Most residents in Taita Hills are farmers. Out of the 45 respondents in this study 32 told their occupation to be a farmer. Agriculture is very dependent on water and it is probably one of the biggest reasons why the people of Taita Hills consider water to be such an important element in their lives. There are two natural rain seasons and two drier seasons in Taita Hills, so the people have learnt to schedule their lives according to these climatic conditions that dictate the timing of rainfall and determine the overall water availability. Most concerns that people had regarding water resources were linked to agriculture.

Water was an important aspect of biodiversity for many respondents, too. Diversity of nature was understood as pure, clean environment by about a fourth of the respondents. In their answers the role of clean water and fresh air was highlighted. Water was mentioned in the other categories of biodiversity understanding, too. People who saw nature as a source of concrete benefits included water to be one of these benefits. The respondents who emphasized the biological and ecological relationships of nature in regards to biodiversity said that water enables many of these processes to happen. Respondents beholding a spiritual idea of biodiversity also recognized the importance of water in an environment and accentuated certain species' roles as protectors of water resources or the beautifulness water brought to the environment. Water was the one element that connected all these views of biodiversity.

7.4 Biodiversity

Respondents tended to associate biodiversity with the diversity of tree species and forests in particular; diversity of nature meant different kinds of trees and forests to many of them. Plants and especially tree cover have been noticed to be the most important aspects of biodiversity to people in previous studies as well (Dallimer et al. 2012; Fuller et al. 2007). The respondents' conception of biodiversity was highly associated with plants. Another association the respondents made concerning biodiversity was to link it with untouched nature. Untouched nature in turn they linked to aesthetic values. Attractiveness of nature was also an important aspect of biodiversity to the respondents which corresponds well with the results of previous studies, too (Lindemann-Matthies et al. 2010).

Most respondents (43 out of 45) appreciated a diverse environment in terms of plant species which can be understood as appreciation of biodiversity. In Wundanyi and Mwanda study areas there was one respondent, respectively, who considered an environment with just a few different plant species preferable to an environment with lots of different plant species. In Wundanyi study area the reason given for that was that diversity of species can make the place cold and in Mwanda study area the respondent thought that there is no room for lots of different trees because of settlement. Both of these reasons are human-oriented and can therefore be strongly linked to ecosystem services. As none of the forty-five respondents expressed that biodiversity itself could somehow be undesirable it can also be acknowledged that people of Taita Hills in general think biodiversity is a good thing that increases their well-being.

7.4.1 Biodiversity plays a big and varying role in people's lives

The respondents approached the idea of biodiversity from very different viewpoints. Personal gain, ecological relationships and spiritual values were all included in their answers concerning the meaning of biodiversity. Diversity of nature can mean different things to different people (Fisher et al. 2009) which means it can produce different ecosystem services for different people. The definition of ecosystem services by Fisher et al. (2009) can also be considered here. They stated that ecosystem service can only exist if there are people who see it as a benefit. For instance if there is a beautiful scenery somewhere but nobody can see it, it cannot be counted as an ecosystem service. The difficulty with biodiversity comes with the previous finding: biodiversity is different for different people. According to Fisher et al. (2009) ecosystem services produced by biodiversity vary greatly depending on the people linked to it and this would make it extremely difficult to identify ecosystem services produced by biodiversity objectively. In this study different perceptions of biodiversity were however identified and categorized. Ecosystem services produced by biodiversity were also tried to identify by looking at the concept from different viewpoints.

The four viewpoint categories concerning biodiversity and presented in Table 8 can roughly be linked to the four ecosystem service categories by MA (2005b) as follows:

“Good and clean life”	↔	Regulating services
“Benefits to people”	↔	Provisioning services
“Ecological/biological”	↔	Supporting & regulating services
“Spiritual”	↔	Cultural services

This means that biodiversity can be directly linked to all ecosystem service categories when it is examined objectively. It further promotes the idea of biodiversity belonging to supporting services, services that enable the existence of other ecosystem services. It also promotes the idea that it is important to protect biodiversity as it affects people’s well-being in such a multifaceted way. As we can see from Table 8, biodiversity can produce different kinds of ecosystem services depending on the viewpoint in question. According to MA (2005b) biodiversity is not directly placed into any of the four categories. By definition it would fit best to the category of supporting services, services that are necessary for the production of all other ecosystem services. However, according to MA (2005b) supporting services are not directly used by people but only provide indirect benefits to them. Biodiversity seems to give also direct benefits to people e. g. through its existence value which makes it unsuitable for the definition of supporting services.

Negative aspects of biodiversity were also identified through the interviews. Majority of the respondents thought that biodiversity cannot be harmful but there were twelve respondents who thought that biodiversity also has its cons. Six of these twelve respondents were from Ngangao study area. The reasons given for biodiversity's harmfulness varied all the way from dangerous animals to floods but two motives were the most prominent according to the respondents; 70% of the respondents who thought biodiversity can be harmful named crop damage or dangerous animals to be the reason for that. Crop damage (or pest damage) was one of the disservices linked to agriculture in Fig. 11. Dangerous animals could be considered disservices produced by biodiversity by offering habitats for animals that can hurt people. Both reasons mentioned above are very human-oriented and can be consequently linked to ecosystem services. Other reasons given to harmfulness of biodiversity were sicknesses such as flu caused by flowers, water and nutrient scarcity, floods and the possibility that animals could hurt each other. Sicknesses caused by nature (e. g. pollen allergy) are direct disservices to people. Water or nutrient scarcity and floods are indirect disservices to people and the possibility that animals could hurt each other in a diverse environment is more of a biological viewpoint of biodiversity. Consequently 94% of the respondents who thought biodiversity can be harmful named reasons affecting people directly or indirectly. Their perspective was therefore very human-oriented and the majority approached the question from the viewpoint of human well-being.

7.5 Introduced species dividing opinions in Taita Hills

Previous studies show that urbanized areas often contain lots of exotic, non-native species (McKinney 2008). This could be partially seen in this study as well because the prominence of the exotic *Eucalyptus sp.* was the most obvious in the "urban" study area of Wundanyi. However, *Acacia mearnsii* that was the most noted species in Ngangao and Mwanda study areas is also an exotic tree species in Taita Hills. Overall the exotic study species were much more used and known than indigenous ones when the respondents were asked to name just one species they used the most or knew the best. This suggests that the exotic plant species that have spread to Taita Hills in the past have now gained a permanent position in the ecosystem.

In Wundanyi study area people were most against bringing new, strange species to Taita Hills (Fig. 30). Interestingly, most of the respondents (nine out of fifteen) in Wundanyi study area also thought that there are more exotic than indigenous plant species in Taita Hills (Fig. 30). This indicates that the residents of Wundanyi area have had bad experiences with exotic plant species or there have been rumors about the harms of introduced species overwhelming the area. The question whether there really are more exotic or indigenous plant species depends on the definition (number of the species, biomass of the species etc.). There have been no comprehensive studies about the subject in Taita Hills. The object of this study was just to investigate the perceptions of the local people as to whether there are more exotic or indigenous species in Taita Hills.

In Wundanyi study area *Eucalyptus sp.*, one of the most common exotic tree species in Taita Hills, was the most recognized study species. *Eucalyptus sp.* has been linked to adverse effects in environment already before (Himberg 2011) and this could be seen from the results of this study as well; twenty respondents stated *Eucalyptus sp.* to affect hydrology of the area negatively by consuming lots of water. In both Ngangao and Mwanda study areas people were more open to bringing introduced plant species to Taita Hills and in both study areas most respondents (twelve out of fifteen) thought that there are more indigenous than exotic plant species in Taita Hills.

The interview at a local tree nursery revealed that local people buy mostly exotic tree seedlings. As much as 95% of the seedlings bought were exotic and only 5% indigenous. The price of exotic tree seedlings was 15 Ksh and the price of indigenous tree seedlings was 20 Ksh. Based on these percentages of exotic and indigenous seedlings bought local people seem to prioritize the price of the seedling over its nativeness. A study by Fischer et al. (2011) discovered that nativeness of a species does not affect its desirability much; value and harmfulness of a species play much bigger roles in its desirability as was already pointed out earlier. Based on other results of this study people's perception of nativeness of a species seemed to be quite neutral as well. There was no real differentiation between exotic and indigenous species when it came to biodiversity or ecosystem services produced.

7.6 Assessing validity and reliability of the methods used and results obtained

Validity and reliability are important aspects of any given study. Acknowledging possible flaws and inconsistencies of research facilitates future research on the subject and adds credibility to the study in question. In this chapter I have tried to identify both different kinds of challenges and difficulties I faced during this thesis as well as aspects of the study that went well regarding both methods used and results obtained.

The method used to collect data for the thesis was a semi-structured interview study. Total number of completed interviews was forty-six; forty-five household interviews and one tree nursery interview. The limited time available to spend in Taita Hills dictated the number of interviews to some degree, but it felt that forty-six interviews was enough to get an idea of the perceptions local people have of ecosystem services, biodiversity and introduced species of the area. This could be seen from the saturation of data during the interviews; the answers began to repeat themselves towards the end and additional interviews probably would not have changed the results significantly. Triangulation of the data was also used in small scale to improve both reliability and validity of the study. This is why in addition to the forty-five household interviews one interview was conducted at a local tree nursery. The idea was to get some insight in the mindsets of different stakeholders about the same subject. The household interviews were divided into three smaller study areas inside Taita Hills. It could be seen that even in this small scale division there were differences in results between the study areas. It was therefore a correct choice to divide the interviews between these three study areas because it increased the data obtained and enabled comparison of the results.

Interpretation was used during most interviews (from English to Swahili/Taita language). When questions are translated into another language they may lose some of the original meaning in the process which can add error to the results. As the questions were sometimes asked in English and sometimes in Swahili/Taita language, they may not have been asked exactly the same way with all the respondents. Attention was paid that all questions were asked as similarly as possible with all the respondents but this could not completely be achieved due to the non-formal nature of the interviews.

During the interviews, the recognition of the study species was entirely based on the pictures shown to the respondents (Appendix 2). Some of the pictures might have been better at capturing the appearance of the species than others meaning that the answers could also have varied because of the quality of the shown pictures. For instance in the case of *Albizia gummifera*, it seems that quite many respondents were a bit confused by the picture shown to them. The picture did not display *Albizia gummifera* as a grown tree but showed only some leaves of the plant as can be seen from Appendix 2, which might have affected people's recognition of the species. The same thing probably happened to some extent with *Ficus sur*, as many respondents were unsure about its picture as well. Nevertheless, all the respondents were shown the same pictures which added comparability to the study and made it easier to be objective about the answers. The pictures were always shown in a random order to the respondents. It was probably easier for them to express their opinions on the last pictures shown than the first ones as they already knew what the purpose of the questions was at that point.

Roadside bias is a common source of error in interview studies. In this study it might have affected the results especially in Mwanda study area where almost all fifteen interviews were conducted near roads. The sampling at the time of the interviews was random and the bias was detected only afterwards.

This study focused on a small amount of specific species and the results mirror that. Data obtained from part one of the household interviews and the whole tree nursery interview touches only the eleven study species in question, which means that it cannot fully describe the overall attitudes towards ecosystem services in Taita Hills. The study species were chosen to represent different families, origins and sizes, though, which broadens the scope of the results.

8. Conclusions

People of Taita Hills were well aware of the various ecosystem services produced by their environment. They recognized mostly provisioning services but also many regulating and cultural services. Probably none of the respondents knew the scientific definition of the term "ecosystem service" but their answers proved that the concept is familiar with them despite their lack of scientific knowledge about the topic. This promotes the comprehensibility of the concept as regular people understand its meaning without the need to explain it individually. Some aspects of the concept were less familiar to the respondents than others (e. g. the most complex regulating services such as carbon storage), though, but the main idea seemed to be quite well understood.

Biodiversity was an important aspect of nature to the respondents of this study and they saw it almost unanimously as a positive thing. Biodiversity is a big source of ecosystem services in the area, especially because Taita Hills belong to one of the 25 biodiversity hotspots of the world. The large variety of plant and animal species is being utilized and appreciated there in both concrete and abstract ways.

Biodiversity and ecosystem services are intertwined in multiple ways in Taita Hills region. The linkages are mostly positive even though some ecosystem services might benefit from the reduction of biodiversity in the area (e. g. food production). One important thing connected to both biodiversity and ecosystem services was water. The respondents linked it with many different ecosystem services and felt it was an important aspect of biodiversity, too. Local people's perceptions of biodiversity were strongly linked to the benefits and disadvantages gained from it which makes their perceptions correspond well with the idea of ecosystem services (and disservices). Overall the multi-faceted nature of both ecosystem services and biodiversity was well represented in the answers of local people.

Future research on ecosystem services and biodiversity in Taita Hills area could concentrate on further assessing local people's perception of biodiversity through more comprehensive inquiry studies. By increasing the sample size the results would become more reliable and comparison between smaller areas inside Taita Hills could be done. It could be interesting to find out how species from different kingdoms, especially Animalia, would affect people's perception of biodiversity. Interesting species that came up during the interviews and could also be further studied in the area were e. g. *Prunus Africana* (a common indigenous tree species) and *Grevillea robusta* (widely used exotic tree species). On a larger scale it could be interesting to find out if the vegetation zones of the Earth dictate how people feel about biodiversity because studies have shown that plants and trees have a substantial role in people's perception of their environment (Dallimer et al. 2012). Knowledge about the subject could give decision-makers valuable information on how to approach projects taking place in different regions of the world.

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Appendix

Appendix 1a. The question form of the household interviews.

BACKGROUND INFORMATION		
Age:	Gender:	
Occupation:	Household size:	
Area of land owned (farmland/forest/other):		
Do you visit the nearby forests often? How often?	□ daily □ weekly □ monthly	
PART 1		
1. Do you use lots of collected plants in your everyday life?		
2. How do you use them?		
3. Do you recognize the following study species?		
a) *Acacia mearnsii* b) *Albizia gummifera* c) *Eucalyptus sp.* d) *Ficus sur*	e) *Impatiens teitensis* f) *Orthostichella sp.* g) *Phoenix reclinata* h) *Pteridium aquilinum*	i) *Ricinus communis* j) *Tithonia diversifolia* k) *Usnea sp.*
4a-k. How can you use it? Does it have any other value to you?		
5a-k. Have you sold the species to someone?		
6a-k. Is the species harmful to you in some ways?		
7a-k. From where have you learnt to use the species?		
8a-k. How much (Ksh) would you say the species is worth to you?		
9. Which of these species is the most/least familiar to you? Why?		
10. Which of these species do you use the most? And the least? Why?		
PART 2		
11. Do you think it's good for the environment to bring new strange plant species to Taita Hills?		
12. Are there more indigenous or exotic plant species in Taita Hills?		
13. Would you prefer an environment with only a few different plant species or a more abundant assortment of plants? Why?		
14. What does diversity of nature mean to you?		
15. Do you value diversity of nature? Is it beneficial to you in some ways? Or harmful?		

Appendix 1b. The question form of the tree nursery interview.

1. Do you sell the seedlings of these species?		
a) *Acacia mearnsii* b) *Albizia gummifera* c) *Eucalyptus sp.* d) *Ficus sur*	e) *Impatiens teitensis* f) *Orthostichella sp.* g) *Phoenix reclinata* h) *Pteridium aquilinum*	i) *Ricinus communis* j) *Tithonia diversifolia* k) *Usnea sp.*
2. How much do they cost?		
3. Do you sell more indigenous or exotic seedlings?		
4. Which ones are more expensive?		
5. Which ones do people buy more?		
6. Where do you get your seedlings from?		
7. How often do people ask if the seedling is indigenous or exotic?		
8. Which seedling is your bestseller?		

Appendix 2. Pictures shown to the respondents during the household interviews. Photographs by J. Rikkinen.

Acacia mearnsii

Albizia gummifera

Eucalyptus sp.

Ficus sur

Impatiens teitensis

Orthostichella sp.

Phoenix reclinata

Pteridium aquilinum

Ricinus communis

Tithonia diversifolia

Usnea sp.

Appendix 3. Respondents' views on ecosystem services provided by the study species. They have been categorized according to the ecosystem service categories and sub-categories of MA (2005b). If a service can be considered to belong to more than one category, other possible categories can be found in brackets.

Ecosystem service (by categories, a-z)	**Sub-category** (MA 2005b)	**Study species**	**Number of mentions** (max 45, except for "umbrella services")	**Study areas** (W=Wundanyi, N= Ngangao, M=Mwanda)
Provisioning services				
base for funeral flowers	fiber, (CS: spiritual and religious values)	*Orthostichella sp.*	1	M
beddings	fiber	*Phoenix reclinata, Pteridium aquilinum*	6	W, N
beehives	fiber	*Albizia gummifera, Ficus sur*	2	N, M
bird nest	fiber	*Usnea sp.*	1	M
brew	food	*Phoenix reclinata*	1	N
charcoal	fuel	*Acacia mearnsii, Eucalyptus sp.*	6	W, N
construction			73	
granary	fiber	*Phoenix reclinata*	*4*	W, N
pole	fiber	*Acacia mearnsii, Albizia gummifera, Eucalyptus sp., Phoenix reclinata*	*14*	W, N, M
timber	fiber	*Acacia mearnsii, Albizia gummifera, Eucalyptus sp.*	*40*	W, N, M

traditional house	fiber	*Phoenix reclinata*	*15*	W, N, M
contraceptive	biochemicals, natural medicines and pharmaceuticals	*Ricinus communis*	3	W, N, M
fencing	fiber	*Eucalyptus sp., Phoenix reclinata, Tithonia diversifolia*	6	W, N, M
firewood	fuel	*Acacia mearnsii, Albizia gummifera, Eucalyptus sp., Ficus sur, Impatiens teitensis, Phoenix reclinata, Ricinus communis, Tithonia diversifolia*	44	W, N, M
fodder	food	*Acacia mearnsii, Albizia gummifera, Pteridium aquilinum, Ricinus communis, Tithonia diversifolia*	21	W, N, M
fruits	food	*Acacia mearnsii, Ficus sur, Phoenix reclinata*	34	W, N, M
furniture	fiber	*Eucalyptus sp., Phoenic reclinata*	4	W, N, M
glue	fiber	*Acacia mearnsii*	1	M
gum	food	*Acacia mearnsii*	3	W, M

honey	food	*Impatiens teitensis, Ricinus communis, Tithonia diversifolia*	4	W, N, M
insecticide/fungicide	biochemicals, natural medicines and pharmaceuticals	*Tithonia diversifolia*	13	W, N, M
kindling	fiber, fuel	*Pteridium aquilinum*	1	W
ladder	fiber	*Phoenix reclinata*	1	N
lid when fetching water	fiber, (CS: knowledge systems)	*Pteridium aquilinum*	1	M
medicine	biochemicals, natural medicines and pharmaceuticals	*Acacia mearnsii, Albizia gummifera, Eucalyptus sp., Ficus sur, Impatiens teitensis, Pteridium aquilinum, Ricinus communis, Tithonia diversifolia, Usnea sp.*	26	W, N, M
oil	biochemicals, natural medicines and pharmaceuticals	*Ricinus communis*	35	
castor-oil			*12*	W, N, M
hair oil			*2*	W, M
lotion/oil on skin			*14*	W, N, M
lubrication oil			*2*	M
not specified			*5*	W, N
ornament	ornamental resources,	*Impatiens teitensis,*	10	W, N, M

	(CS: aesthetic values)	*Orthostichella sp., Ricinus communis, Tithonia diversifolia*		
padding on head	fiber, (CS: knowledge systems)	*Pteridium aquilinum*	5	W, N
shoe polish	fiber	*Acacia mearnsii*	13	W, N, M
small products			58	
basket	fiber	*Phoenix reclinata*	*28*	W, N, M
broom	fiber	*Acacia mearnsii, Phoenix reclinata*	*9*	W, N, M
drum	fiber	*Albizia gummifera, Ficus sur*	*1*	M
handle for farm equipment	fiber	*Albizia gummifera*	*1*	N
carpet/mat	fiber	*Phoenix reclinata, Pteridium aquilinum*	*11*	W, N, M
rope	fiber	*Phoenix reclinata*	*2*	W, N
toothbrush		*Acacia mearnsii, Albizia gummifera, Eucalyptus sp.*	*5*	W, N, M
toy car		*Albizia gummifera*	*1*	M
Regulating services				
air purification	air quality maintenance	*Albizia gummifera*	1	N
erosion control	erosion regulation	*Eucalyptus sp., Ficus sur, Phoenix reclinata, Pteridium aquilinum*	3	W, M
nectar	pollination	*Acacia mearnsii, Albizia*	11	W, N, M

		gummifera, Impatiens teitensis, Ricinus communis, Tithonia diversifolia		
rain attraction	water regulation, (CS: spiritual and religious values)	*Ficus sur*	3	W
shade provision	climate regulation	*Albizia gummifera, Ficus sur, Phoenix reclinata, Pteridium aquilinum, Ricinus communis*	7	W, N, M
water retention	water regulation	*Albizia gummifera, Eucalyptus sp., Ficus sur, Orthostichella sp.*	13	W, N, M
Cultural services				
bush baby diversion	knowledge systems	*Ficus sur*	1	M
catholic religion, e. g. weaved crosses	spiritual and religious values, (CS: educational values)	*Phoenix reclinata*	5	M
plant covering	knowledge systems	*Phoenix reclinata, Pteridium aquilinum*	4	N, M
tie vegetables	knowledge systems, (PS: fiber)	*Phoenix reclinata*	1	W
water filtering	knowledge systems	*Pteridium aquilinum*	1	W
Supporting services				
manure	soil formation	*Acacia mearnsii,*	15	W, N, M

		Impatiens teitensis, Pteridium aquilinum, Tithonia diversifolia		
mulch	soil formation	*Acacia mearnsii, Phoenix reclinata, Pteridium aquilinum*	4	W, N
soil nutrients	soil formation	*Orthostichella sp., Pteridium aquilinum, Tithonia diversifolia*	2	W, N